

Gender Trends in Academic Radiology Publication in the United States Revisited

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Rationale and Objectives: Although substantial increases in publications by female academic radiologists have appeared over the last several decades, it is possible that the rate of increase is decreasing. We examined temporal trends in gender composition for full-time radiology faculty, radiology residents, and medical students over a 46-year period.

Methods: We examined authorship gender trends to determine if the increases in female authorship seen since 1970 have been sustained in recent years and whether female radiologists continue to publish in proportion to their numbers in academic departments. Original articles for selected years in *Radiology* and in the *American Journal of Roentgenology* between 1970 and 2016 were examined to determine the gender of first, corresponding, and last authors. Generalized linear models evaluated (1) changes in proportions of female authorship over time and (2) associations between proportions of female authorship and female radiology faculty representation.

Results: While linear increases in first, corresponding, and senior authorships were observed for female radiologists from 1970 to 2000, the rate of increase in female first and corresponding authorships then changed, with the slope of the first author relationship decreasing from 0.81 to 0.34, corresponding to 47% fewer female first authors added per year. In contrast, the proportion of female last authorship continued to increase at the same rate. The proportion of female first authorship was linearly related to the proportion of female radiology faculty from 1970 to 2016.

Conclusions: Annual increases in first author academic productivity of female radiologists have lessened in the past 16 years, possibly related to reductions in the growth of female radiology faculty and trainees. As mixed, compared to homogeneous gender, authorship teams are associated with more citations, efforts to encourage more women to pursue careers in academic radiology could benefit the radiology research community.

Key Words: Sex; productivity; research; advancement; workforce.

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BACKGROUND

Academic radiology has experienced increases in both absolute number and relative proportion of female radiology faculty and residents over the past several decades. In addition, a recent study exploring the effects of gender diversity on research productivity found that gender-heterogeneous working groups can produce higher-quality science, as evidenced by higher numbers of citations (1). This result underscores the importance of continuing to strive for

gender parity in radiology departments. Although the increased female representation in radiology departments seems promising with respect to research quality, women still remain underrepresented at the associate professor and professor ranks and in upperlevel radiology department administration (<https://www.aamc.org/members/gwims/statistics/> (2)). Authorship can profoundly influence career trajectory in academic radiology. Moreover, academic productivity can profoundly influence decisions regarding faculty recruitment, hiring, and promotion (3). In addition, recent evidence suggests that salary determinations for medical school faculty can be influenced by publication productivity (4).

Publication of original research in peer-reviewed scientific journals is an important objective measure of academic productivity (3,5). Author placement also has implications for accountability and allocation of credit and can be used in determining worthiness for promotion, allocated research time, and research funding (3,6). With the exception of a minority of journals that list authors alphabetically, most journals list authors according to the author-rated level of contribution (7). The designation of first author is important because first authors generally make substantial contributions to every

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element of the research except provision of resources (8). Many studies are known by the name of their first author, lending credence to the idea that the first author plays an instrumental role in performing the work and in writing the manuscript (9).

Recent examinations of gender trends in radiology authorship found linear growth in female first and last authorships in *Radiology* and in the *American Journal of Roentgenology* (AJR) over extended time periods (10,11). Neither Piper et al.'s nor Liang et al.'s study, however, included data from recent years, and there was a suggestion in the published results that the academic productivity of female radiologists may be leveling off (10,11). The proximate effects of academic productivity on professional success compelled us to further investigate this possible developing trend.

The present study revisits the gender distribution of authors publishing original research in two academic radiology journals over the past four decades, examining the evidence that female radiologists may have reached a plateau in their academic productivity in more recent years. Because practices regarding authorship order vary across scientific groups, we investigated first, last, and corresponding author effects. Our study focused on first author trends, as first authors generally have the greatest participation and are generally responsible for planning the study, performing the study, including data acquisition and analysis, and drafting the manuscript (7). To explore the potential consequences of decreasing rates of female authorship, we investigated the effects of authorship team gender diversity on subsequent publication citation rates.

METHODS

After receiving local institutional review board approval, original basic science and clinical research articles from the journals *Radiology* and *AJR* from the years 1970, 1980, 1990, 2000, 2004, 2005, 2010, and 2013–2016 were retrospectively reviewed. Original research in all subspecialties of radiology, health policy and practice, medical physics, and technical developments were included in the resulting dataset. Editorials, case reports, pictorial essays, and review articles were excluded from the sample. Special editions or supplementary issues were also excluded from the analysis. These journals were chosen because of their high-impact factor among radiology journals (7.3 and 2.8, respectively, according to Journal Citation Reports® Science Edition (Clarivate Analytics, 2018)) and their distinction in the radiology community as sources of current, clinically relevant, and high-quality research. The years selected were chosen to allow comparison to authorship studies completed in other fields (12,13). Data for the year 2005 were included after inspection of trends from other years suggested that publication estimates for 2004 may have been atypical. The years 2013–2016 were included to better model the possibility of recent reduced growth rates in female productivity.

For each article examined, first, corresponding, and last author genders, graduate degrees, and institutional affilia-

tions were determined. We focused on first and last authors, as they tend to have the highest levels of participation, with the senior investigator traditionally last in the author list to denote their supervisory position in the work (7). The corresponding authors were also determined for each article, because this author takes primary responsibility for communication with the journal during the manuscript submission, peer review, and publication process, and typically ensures that all the journal's administrative requirements are met. Nevertheless, not all radiology groups follow these authorship guidelines. Because criteria for authorship position can vary widely among laboratories, we examined temporal trends in multiple authorship outcome measures.

Gender was determined by initial inspection of first name. In cases where gender could not be determined by inspection, searches of the author's affiliated institutional website and internet searches using the Google search engine were performed to verify gender. In accordance with previously published studies on this topic, our analysis of original articles was restricted to investigators from U.S. institutions holding M.D. or equivalent degrees, including resident and fellow trainees, because our datasets regarding gender of academic radiologists, radiology residents, and medical students are limited to U.S. institutions. For *AJR*, we also used Google searches to determine academic degrees, which were not available in the published articles. Authorships for which gender could not be determined were excluded from analysis.

Statistical Methods

To determine if the *type of female authorship changed with time*, we used binomial logistic regression to examine linear and quadratic temporal publication trends in female first, last, and corresponding authors over the same time period. The journal of publication was included in these models as a fixed effect.

To determine if there was a *rate change in female authorship with time*, we used segmented regression, a method in which the predictor variable is partitioned into intervals and a separate line fit to each interval (14). Also called piecewise regression, segmented regression can be used to explore how outcome variables exhibit changing relationships across variations in predictor variable values. Segmented regression provides an objective method to determine segment boundaries, also called breakpoints.

To determine if *female workforce proportions at different training levels changed with time*, we used a Tobit censored regression model (15) to examine linear and quadratic temporal trends in the proportion of female medical students (available from [https://www.aamc.org/members/gwims/statistics/\(2\)](https://www.aamc.org/members/gwims/statistics/(2))), radiology trainees (16–27), and radiology faculty ([https://www.aamc.org/data/facultyroster/reports\(28\)](https://www.aamc.org/data/facultyroster/reports(28))) from 1970 to 2016. The Tobit model is used in situations in which the outcome variable values may be truncated near boundaries.

To examine how *female authorship proportion was associated with female faculty proportion*, we used binomial regression with

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