## Title

Gender Differences in Number of Citations Per Paper Among Well-Cited Researchers in Cardiology in the United States (1960 to 2018)



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## Gender Differences in Number of Citations Per Paper Among Well-Cited Researchers in Cardiology in the United States (1960 to 2018)

Previous research has found gender differences in faculty rank among researchers in cardiology in the United States (US).[1] Explanations include differences in research productivity stemming from differences in institutional support and in distribution of household responsibilities, lack of mentorship and role models for women, and gender bias in the grant review process.[1,2] Although such barriers may limit the number of papers female researchers publish, less is known about gender differences among researchers in cardiology in number of citations per paper for the papers they do publish, another metric that institutions may consider when evaluating researchers. This study estimated gender differences in the number of citations per paper among well-cited researchers in cardiology in the US.

We used a publicly available database of 100,000 most-cited researchers across all scientific fields.[3] The database includes, by author, number of papers published since 1960 and number of citations since 1996. We used validated software (Genderize.io [https://genderize.io]) to predict gender, keeping names with a probability of the predicted gender of at least 60% as done in previous papers;[4] we assigned a gender to 96.1% of the sample. In sensitivity analyses, we kept names with a probability of predicted gender of at least 90%, although the former threshold was used in the main analyses to increase statistical power. We limited our sample to US researchers whose scientific field was "cardiovascular system and hematology;" a review of the first 150 researchers by number of citations showed that only 3 were researchers in hematology. We further limited the sample to researchers whose first publication was on or after 1960.

We examined gender differences in the total number of published papers, total number of citations, and citations per paper (total number of citations [excluding self-citations] divided by total number of papers). Self-citations were defined by creators of the database as citations to a paper by any author of the cited paper. We first estimated a multivariable linear regression of average citations per paper as a function of gender, controlling for researcher experience (defined as 2018 − year of first publication). We then estimated differences between the 10th percentile, 25th percentile, 50th percentile, 75th percentile, and 90th percentile of the female distribution to the same percentiles of the male distribution of citations per paper using multivariate quantile regression. The

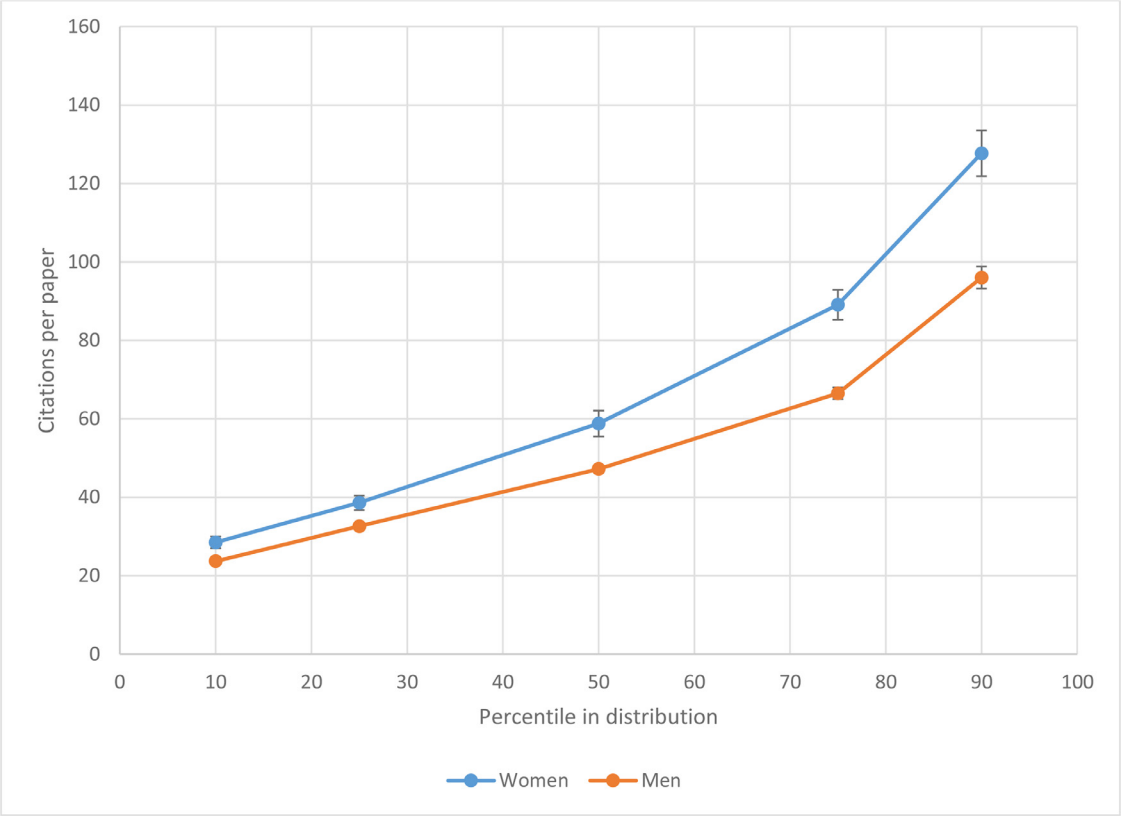


Figure 1. Gender differences in ratio of citations to papers by percentile in the distribution among top US researchers in cardiology.
Note: Author's calculation using data from Ioannidis et al's publicly available database of 100,000 most-cited researchers across all scientific fields based on a composite indicator of 6 citation metrics (total citations; Hirsch h-index; co-authorship-adjusted Schreiber hm-index; number of citations to papers as single author; number of citations to papers as single or first author; and number of citations to papers as single, first, or last author). Number of citations was limited by creators of the database used to citations between 1996 and 2018. Self-citations were defined by creators of the database used as citations to a paper by any author of the cited paper. Multivariable quantile regressions were performed for each percentile (10th, 25th, 50th, 75th, 90th), controlling for experience. Experience is defined as 2018-year of first publication. The bars are 95% CIs.

University of California, Los Angeles Institutional Review Board determined that this was not human subjects research.

Our sample included 1,555 well-cited researchers in cardiology (217 women and 1,338 men). The average experience was 32.8 years for women and 37.0 years for men. The average number of publications was 239 for women and 295 for men; the median number of papers was 190 and 240, respectively. The average number of citations excluding self-citations was 16,750 for women and 16,308 for men. The ratio of nonself citations to number of papers was 69.7 for women and 56.8 for men. When controlling for experience, women had on average 42 fewer publications (95% confidence interval [CI] −66 to −18) than men but had a higher ratio of citations to papers (68.1 vs 57.1; difference of 11.0 [95% CI 4.9 to 17.2]). The difference in the 75th percentile of distribution of our outcome of citations to publications between female and male researchers in cardiology was 89.1 versus 66.5 (difference of 22.7; 95% CI 14.7 to 30.7), whereas the difference in the 90th percentile was 127.7 versus 96.0 (difference of 31.7 [95% CI 19.3 to 44.1]) (Figure 1). Results were unchanged when keeping researchers with a probability of predicted gender of at least 90%, when not excluding self-citations, and when estimating a Poisson model for count data.

In conclusion, in our sample of well-cited US researchers in cardiology, we found that although male researchers had higher productivity as measured by number of published papers, female researchers had a higher ratio of citations to papers, with larger differences when examining the upper end of the distribution. These results imply that although well-cited female researchers in cardiology do not write as many publications as male researchers, the publications they do write may have greater impact. Given known gender differences in professional barriers faced by US researchers in cardiology, institutions may consider emphasizing citation-weighted measures of research productivity in the promotions process. These results are limited to this sample of highly cited researchers in cardiology and may not generalize US researchers in cardiology more broadly. Other limitations include use of gender as predicted by name rather than use of self-identified gender and use of a category of researchers that has a very small percentage of researchers in hematology.

## Disclosures

The author has no conflicts of interest to declare.

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