Women in Contemporary Cancer Research

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short title: Women in cancer research.

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Abstract

Despite recent advances, gender inequality persists in many scientific fields, including medicine. Thus far, no study has extensively analyzed the gender composition of contemporary researchers in the oncology field. We examined 40 oncological journals (Web of Science, ONCOLOGY category) with different impact factors (Q1-Q4) and extracted all the articles and reviews published during 2015-17, in order to identify the gender of their authors. Our data showed that women represent about 38% of all the authorships, both in articles and reviews. In relative terms, women are overrepresented as first authors of articles (43.8%), and clearly underrepresented as last or senior authors (<30%). This double pattern, also observed in other medical fields, suggests that age, or more specifically, seniority, may play some role in the gender composition of cancer researchers. Examining the pattern of collaboration, an interesting finding was observed: the articles signed by a woman in the first or in the last position roughly showed gender parity in the byline. We found also some differences in the content of the articles depending on which gender occupies the first and last positions of the authorships.

Key words: women, gender, cancer, oncology.

Introduction

In the past few decades, there has been a growing interest in studying and supporting the participation of women in scientific research[1]. Nevertheless, despite important advances, gender imbalance persists in the research production in many scientific fields[2], including medicine[3-5]. Examples of this interest in gender diversity in science would be the fact that Nature dedicated a special issue to ‘Women in Science’[6] or that the influential medical journal The Lancet launched a thematic issue on ‘Women in Science, Medicine, and Global Health’[7]. Recently, the FRONTIERS IN CANCER RESEARCH conference (Oct, 2018), organized by the German Cancer Research Center (DKFZ), promoted gender parity by inviting leading women in the field. The result was that 82% of the invited speakers were women, a percentage opposite to the usual rate, according to the organizers[8].

However, what is the actual percentage of women in cancer research? Thus far, no study has extensively analyzed the gender composition of contemporary researchers in the oncology field. To this end, we examined forty oncological journals with different impact factors, and we extracted all the articles and reviews published in a three-year period in order to study the gender of their authors, almost one hundred and fifty thousand items.

Method.

Sample data. We selected 40 journals indexed in Clarivate Analytics' Web of Science (WoS) database. The selection consisted of 10 journals from each quartile (Q1-Q4) of the distribution of journals sorted by their Impact Factor (IF, JCR-2017), within the ONCOLOGY category, specifically, the top ten in each quartile (see journals in Table S1 of Supplementary material). We extracted all the articles (12,080) and reviews (2,939) published in these journals between 2015-17, and we examined their authorships to determine their gender.

Gender identification of authors. It was based on the first (given) names. The WoS, like most scientific databases, does not provide the authors' gender. However, in 2008 the WoS began to include the authors' full names (field tag AF: Author Full Name), although a proportion of records still display only the authors' initials. After a preprocess of normalization that eliminated initials accompanying given names and replaced hyphens with spaces, all the authors' first names were matched through GenderChecker, a database that includes 102,142 worldwide names, classified as male, female, or unisex (acquired from http://genderchecker.com/). This database is being used in research[9-12] and, according to the website, by the UN Refugee Agency. To increase the number of observations, we identified the gender of a large number of authors (about 10% of total), one by one, whose given names had been unmatched or classified as unisex, by locating biographical information or a photo on the Internet (mainly on university or laboratory websites). The accuracy of the gender classifications was tested in a validation study included in the Supplementary material. As mentioned, the information on the authors' gender is not directly provided by the scientific databases and it must be indirectly inferred from the given names. This is a usual procedure in studies of this nature that is not free of errors. However, we assume that the proportion of possible errors (men classified as women, or women classified as men) is small—such as the validation study shows— and there is no reason to presume that these hypothetical mistakes and the missing values (only initials, unisex names, or unmatched names) are not random and they are gender biased. On the other hand, it should be noted that the GenderChecker database used in this study is more conservative than others databases of that type, such as API Gender (i.e., some names that API Gender classifies as male or female, GenderChecker classifies them as unisex in order to reduce possible errors).

Procedure. Each variable of interest (author names and surnames, type of paper –article or review–, title, year of publication, journal, keywords, etc.) was extracted using the BibExcel program[13]. This software is a toolbox that creates a file in which the values of an extracted variable are associated with each individual paper (identified with a number). Finally, the values of all the variables studied were merged in a master Excel database to perform the bibliometric analyses.

Data availability.

The data that support the findings of this study are openly available in http://www.langproc.uji.es/WCR.html.

Results and Discussion

Rate of women authors. The 12,080 articles extracted from the WoS database were signed by 127,803 authorships; and the 2,039 reviews were signed by 16,497 authorships. From the total 144,300 authorships, and after excluding the authorships with only initials, unisex names, or given names that did not match the GenderChecker database[a], gender could be identified in 112,707 (78.1%) of them: 70,073 men and 42,634 women. Therefore, women represent about **38%** of all the known-gender authorships[b], both in articles and reviews (Table 1, last row), which it is quite far from gender parity, but a somewhat larger proportion than the overall presence of women in science, a third of researchers[2]. Women constitute about half of U.S. medical students[14] – although the number of female applicants and matriculants has declined slightly in the last last years[15]. Bearing in mind that women today represent 49% of the associate members of the American Association for Cancer Research[16], our proportion of 38% female authorships suggests that a gender gap occurs in the number of researchers who publish in peer-reviewed oncological journals.

If we consider the impact factor (IF), no clear trend is observed in the journals grouped by quartiles (Table 1, Figure 1). In articles published in journals categorized within the first quartile (Q1) of the IF distribution, the percentage of women is 36.0%; it rises to 41.4% in the journals in Q2, falls to 36.0% in Q3, and reaches 39.4% in Q4. The

[a] There were 6,597 unisex authorships (4.6% of total), and 24,996 authorships (17.3%) with only initials or unmatched (with the GenderChecker database) given names.
[b] The percentages of female or male authorships will always refer to the known-gender totals.

percentages of women in reviews are 32.8%, 41.0%, 36.2%, and 45.0%, respectively for the four quartiles, Q1-Q4. See journals and data in the Supplementary material.

Please, place Table 1 and Figure 1 about here.

We also obtained the gender percentages as first or last author of the article by-lines. The first and last (or senior) places are usually key positions in many scientific fields, including health and medical sciences, except in fields where the convention calls for alphabetical order (e.g., high-energy physics, mathematics, or economics[17]). Indeed, in our sample, only 1.29% of the articles with three or more authors (or 0.40% of those with four or more authors) present the surnames in alphabetical order, which is not higher than the expected probability of incidental alphabetical authorship.

In relative terms, women are overrepresented as first authors of articles (compared to the overall rate), representing **43.8**% of them (Table 1, last row). This pattern of relative overrepresentation of women as first authors is consistent throughout the four quartiles (Table 1, Figure 1). For example, it is striking that in the oncological journal with the greatest impact in the world (IF=244.586), CA-A CANCER JOURNAL FOR CLINICIANS, although women are less than half of the authors of articles, they represent 56.1% of the first authors; and JAMA ONCOLOGY almost achieves gender parity in its first authors (49.3%) (see Supplementary material). Filardo and colleagues[3] observed that female first authorship increased significantly from 27% in 1994 to 37% in 2014 for articles published in six high-impact medical journals; that proportion of 37% is very close to ours 38% for the ten journals grouped in the first quartile of impact factor (Q1, see Table 1). Jagsi and colleagues examined the participation of women in peer-reviewed research analyzing the authorship of original articles published in six prominent medical journals over a period of 35 years[4]. They only studied first and senior (last listed) authors and found that the proportion of first authors who were women escalated from only 5.9% in 1970 to 29.3% in 2004. Although the Jagsi et al.'s study ended a decade before ours and it was based only on high-impact journals, our proportion of women (43.8%) publishing as first authors in forty journals of different impacts (and 38% in the Q1 category) suggests that perhaps the situation of women – and their future perspectives – in the cancer field is slightly better than in the general medical field. It should be noted that, in biomedical sciences, the first author is typically the one who has made the most significant contribution in terms of work and time dedicated; in many cases, the first authors are beginning researchers publishing their first postdoctoral papers. This relative overrepresentation of women as first authors (and, outstandingly, gender parity in oncological journals of very high impact, such as CA Cancer J Clin or JAMA Oncol) could be indicative of new female incorporations into cancer research publishing their first studies under the direction of senior researchers.

On the contrary, our data show that women are clearly underrepresented as last authors in the article by-lines (compared to the overall rate), both in general (**29.6%**) and consistently for the journals in each quartile (Table 1, Figure 1). In biomedical sciences, this place is usually reserved for the senior or leading scientist on a research team[17], that is, the researcher who conceives the project, coordinates the efforts, supervises the work, etc. This function normally corresponds to a scientist with a consolidated and longer career. The Jagsi et al.'s analysis[4] of articles published in six prominent medical journals found that the proportion of senior (last) authors who were women increased from a tiny 3.7% in 1970 to 19.3% in 2004 (a smaller figure than ours for 2015-17 in cancer field, 29.6%). In other study, Jagsi et al.[18] calculated that only 16% of the editorial board members of sixteen prominent biomedical journals were women in 2005.

The comparative underrepresentation of women occupying senior positions in research teams should be put in relation to other data from academia. According to the Association of American Medical Colleges (AAMC)[19], the current number of full-time faculty at all U.S. medical schools in 2019 are 75,771 (42.3%) women and 103,404 (57.7%) men. The gender proportions by degree type are: faculty with MD only (women, 41.1%, men, 58.9%); faculty with PhD or other doctoral degree (women, 43.8%, men, 56.2%); faculty with MD and PhD, or MD and Other Doctoral Degree (women, 30.0%, men, 70.0%). If we examine the gender distribution of medical faculty by rank[20], there is a clear pyramidal structure: women represent 59.1% of all the Instructors, 47.5% of the Assistant Professors, 38.7% of the Associate Professors, and only 25.7% of full Professors. Curiously, within the male collective the pyramid structure is lost in the last step: there are more full professors (28,595) than associate professors (22,481), presumably as a seniority effect from previous generations.

In summary, this double pattern of relative overrepresentation of women as first authors and relative underrepresentation as last or senior authors, also observed in other gender studies[2,3,5] suggests that **age**, or more exactly, **seniority**, could play some role in the gender composition of cancer researchers. This may be good news in the sense that gender asymmetry could be reduced to a certain degree as new generations of women researchers are gaining seniority.

Please, place Table 2 about here.

Journals. Table 2 presents percentages of women as authors of articles and reviews published during the 2015-17 period in the 40 journals selected for the present study. The journals that showed higher rates of female authors were: the JOURNAL OF ADOLESCENT AND YOUNG ADULT ONCOLOGY, with 67.7% women as authors of articles (82.1% as first authors; and 61.2% as last authors); CANCER EPIDEMIOLOGY BIOMARKERS & PREVENTION (overall: 53.0%, first author: 68.8%, and last author: 51.5%); HEREDITARY CANCER IN CLINICAL PRACTICE (overall: 49.5%, first author: 66.7%); and GYNECOLOGIC ONCOLOGY (overall: 47.3%, first author: 55.1%) (more details in the Supplementary material).

By contrast, the most “masculine” journals were: NATURE REVIEWS CANCER (women only represent 26.4% of the authors of articles, and 30.7% of the authors of reviews); ANNALS OF ONCOLOGY (female percentages: 28.3% in articles and 29.5% in reviews); BONE MARROW TRANSPLANTATION (28.4% in articles and 25.7% in reviews); WORLD JOURNAL OF GASTROINTESTINAL ONCOLOGY (28.4% in articles and 33.0% in reviews); and LUNG CANCER (29.4% in articles and 33.3% in reviews).

Pattern of collaboration. Cancer research is a very collaborative field. The articles from our sample were written by an average of 10.6 authors (15.8 in the journals of Q1), with a range from 1-480 authors; and the reviews were written by an average of 5.6 authors, with a range from 1-358 authors.

Please, place Figure 2 about here.

We selected the articles with at least three co-authors and they were divided into two groups: a) articles signed by a man as first author and b) articles signed by a woman as first author. We repeated the procedure and divided the initial set of multi-author articles into two new groups: c) articles signed by a man as last/senior author and d) articles signed by a woman as last/senior author. Subsequently, we analyzed the gender composition of each group and observed a remarkable finding (Figure 2). **The articles signed by a woman in the first or last/senior position roughly showed gender parity in the byline** (50.1% men/49.9% women when a woman signed as first author, and 46.8% men/53.2% women when a woman signed as last/senior author, which was slightly female biased). We do not mean to say that there is a cause and effect relationship between the presence of women in one of these two key positions and near gender parity in the articles, but obviously these two facts are associated. It seems that leading female researchers tend to co-publish with women more than leading male researchers do; or perhaps they work on subtopics that are relatively more appealing to women.

However, when the first author is a man, the gender composition of the byline is more asymmetrical (70.0% men/30.0% women, Figure 2), compared to the overall asymmetry (62.8% men/37.8% women), X^2(df=1) = 58618.78, $p < 0.0001$. The same thing occurs when a man is the senior or last author of the article (67.5% men/32.5% women, Figure 2), X^2(df=1) = 18191.79, $p < 0.0001$.

If we consider only the first and last authors – without intermediate co-authors – a similar pattern emerges. The articles signed by a man in the senior/last position yield the following percentages: 60% are signed by a man as first author, and 40% by a woman. However, in the articles signed by a woman in the senior/last position the proportions are almost reversed: only 42.4% are signed by a man in the first position, whereas 57.6% are headed by a woman.

Content. We carried out an analysis of the scientific content of each article based on its keywords, specifically, the Keywords Plus assigned by the WoS database (ID field). We separated the keywords belonging to articles signed by a man as first or last author from the keywords belonging to articles signed by a woman as first or last author. Then, the keywords of each set were sorted and grouped by their corresponding frequencies, and we compared the 'male' set vs. the 'female' set to find differences in the relative weight of each keyword (see Table S5 of the Material Supplementary). Thus, the top 5% of the keywords, in both the 'male' and 'female' sets, included the terms: *survival*, *cancer*, *expression*, and *chemotherapy*, but the ‘female’ set additionally contained –in the first place– the keyword *breast-cancer*.

Examining the rest of the keywords, some of the terms with a greater relative weight in the ‘female’ set were, in this order: *women*, *united-states*, *metaanalysis*, *lung-cancer*, *mortality*, *follow-up*, *impact*, *ovarian-cancer*, *risk-factors*, *population*, *care*, *prognostic-factors*, *cohort*, *health*, *prevalence*, *postmenopausal women*, *survivors*, *children*, *recommendations*, *body-mass index*, *physical-activity*, *human-papillomavirus*, or *cervical-cancer*. That is, the articles signed by women as first or last authors tend to deal –more than the articles signed by men as first or last authors– with: a) specific or the most common cancers in women –except *lung cancer*, although not *cell lung-cancer*, which was more prominent in the ‘male’ set –; b) cancer in children; and c) epidemiological and prevention issues. This overall pattern is coherent with gender percentages found in the different journals.

Conclusions.

After identifying the gender of 112,707 authors of 15,019 scientific papers (12,080 articles and 2,939 reviews) published during a three-year period in 40 oncological journals of different impacts, we can draw the following conclusions:

- Women represent about **38%** of authorships, of both articles and reviews, in contemporary cancer research.

- Compared to the overall rate, women are relatively overrepresented as **first** authors (about 44%) and relatively underrepresented as **last or senior** authors (less than 30%).
- The pattern of collaboration of the articles shows an interesting finding: when a woman signs as first or last/senior author, the article authorship approximates gender parity.
- There are some differences in the scientific content of the articles depending on which gender occupies the first and last positions of the authorships.
- The double pattern of relative overrepresentation of women as first authors and their relative underrepresentation as last or senior authors, also found in other studies[2,5,21], suggests that **age**, or more specifically, **seniority**, could play some role in the gender composition of cancer researchers. This is a hypothesis that further research will have to test. In any case, the age/seniority hypothesis would be a positive sign because it would mean that gender proportions could move towards more balanced values in the coming years.

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Conflict of interests:

The authors declare no conflict of interest.

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Table 1. Percentages of Women as authors of Articles and Reviews published during the 2015-17 period in 40 journals selected from the Web of Science database (category ONCOLOGY). The journals are grouped by quartiles (Q1-Q4) according to their impact factor in the ONCOLOGY category (JCR-2017). In the Articles, the table presents overall percentages and percentages of women as first or last authors. Last position values were calculated for articles with at least three co-authors.

	Women (%)			
	Articles			
	Overall	First author	Last author	Reviews
10 Journals (Q1)	36.0%	38.0%	25.9%	32.8%
10 Journals (Q2)	41.4%	51.3%	34.1%	41.0%
10 Journals (Q3)	36.0%	39.6%	27.2%	36.2%
10 Journals (Q4)	39.4%	48.6%	32.0%	45.0%
Total (All Journals)	**37.8%**	**43.8%**	**29.6%**	**37.9%**

Table 2. Percentages of Women as authors of Articles and Reviews published during the 2015-17 period in 40 journals selected from the Web of Science database (category ONCOLOGY). The journals are sorted by their impact factor and grouped by quartiles (Q) in the ONCOLOGY category (JCR-2017). In the Articles, the table presents overall percentages and percentages of women as first or last authors. Last position values were calculated for articles with at least three co-authors. Bold: percentages greater than or equal to 45%. Absolute values are available in the Tables S3 and S4 of the Supplementary material

		Women (%)			
		Articles			Reviews
Q	**JOURNALS (Abbreviations)**	**Overall**	**First author**	**Last author**	
Q1	CA Cancer J Clin	42.9	**56.1**	17.5	**51.8**
	Nat Rev Cancer	26.4	14.3	16.7	30.7
	Lancet Oncol	30.8	26.5	20.5	33.5
	J Clin Oncol	37.6	39.7	29.2	37.9
	Nat Rev Clin Oncol	36.1	40.6	25.0	30.2
	Cancer Discov	38.1	41.1	21.5	22.6
	Cancer Cell	35.0	**46.0**	18.4	11.8
	JAMA Oncol	39.8	**49.3**	30.7	30.0
	Ann Oncol	28.3	25.8	23.1	29.5
	J Natl Cancer Inst	43.1	**45.5**	31.6	33.2
Q2	Cancer Biol Med	38.1	**53.1**	20.7	38.6
	Mol Cancer Res	37.7	**51.2**	23.9	36.8
	J Environ Sci Health C Environ..	40.0	-	-	43.3
	Cancer Epidemiol Biomarkers Prev	**53.0**	**68.8**	**51.5**	**51.1**
	Gynecol Oncol	**47.3**	**55.1**	42.2	**52.2**
	J Oncol	29.4	25.0	30.0	43.8
	Bone Marrow Transplant	28.4	34.9	23.7	25.7
	Crit Rev Oncol Hematol	-	-	-	38.3
	Lung Cancer	29.1	37.3	16.2	33.3
	Front Oncol	38.7	**46.6**	33.1	42.7

(cont.)

Table 2 (cont.).

Q3	Hematol Oncol	41.4	43.3	27.6	40.5
	Surg Oncol Clin N Am	32.4	36.2	19.3	-
	Oncol Res	35.9	35.9	31.6	29.4
	World J Gastrointest Oncol	28.4	29.4	17.9	33.0
	Melanoma Res	**45.3**	**52.4**	35.4	35.1
	Curr Oncol Rep	44.4	**50.0**	**47.1**	40.4
	Hematol Oncol Clin North Am	34.3	44.3	17.9	41.9
	Transl Oncol	35.8	44.9	28.9	31.9
	Am J Transl Res	32.1	31.5	26.1	27.4
	Clin Oncol	31.7	40.4	23.1	17.9
Q4	J Adolesc Young Adult Oncol	**67.7**	**82.1**	**61.2**	**75.8**
	J Contemp Brachytherapy	29.9	36.3	16.1	26.7
	Infect Agent Cancer	43.3	**55.7**	31.8	**54.5**
	Cancer Invest	38.8	44.8	28.5	31.1
	Breast Cancer	32.0	44.3	22.3	44.6
	Front Med	41.5	40.4	34.7	38.1
	Hered Cancer Clin Pract	**49.5**	**66.7**	42.9	**59.5**
	Cancer Control	40.9	37.8	34.7	35.2
	Chemotherapy	33.5	44.1	14.1	37.0
	Curr Oncol	38.6	**51.7**	**46.4**	**45.0**

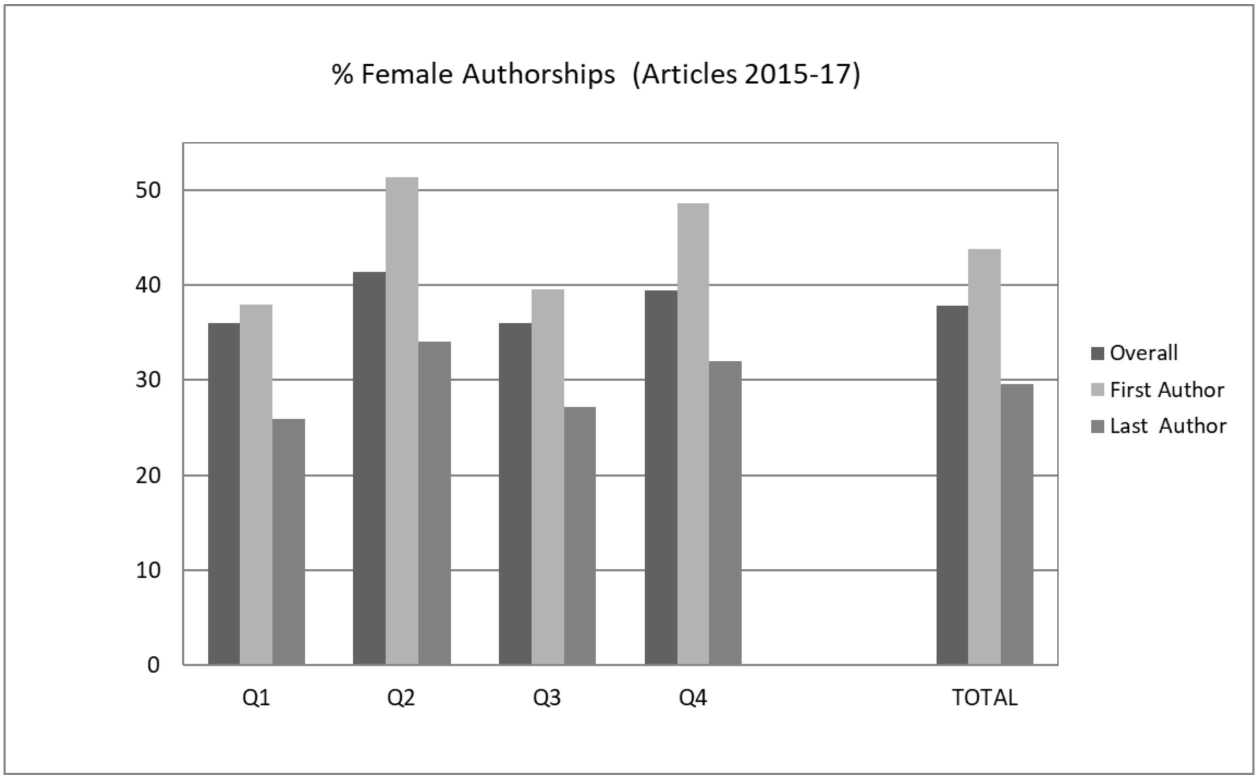

Figure 1. Distribution of percentages of women as authors of Articles published during the 2015-17 period in the 40 journals selected from the Web of Science database (category ONCOLOGY). The journals are grouped by quartiles (Q1-Q4) according to their impact factor in the ONCOLOGY category (JCR-2017).

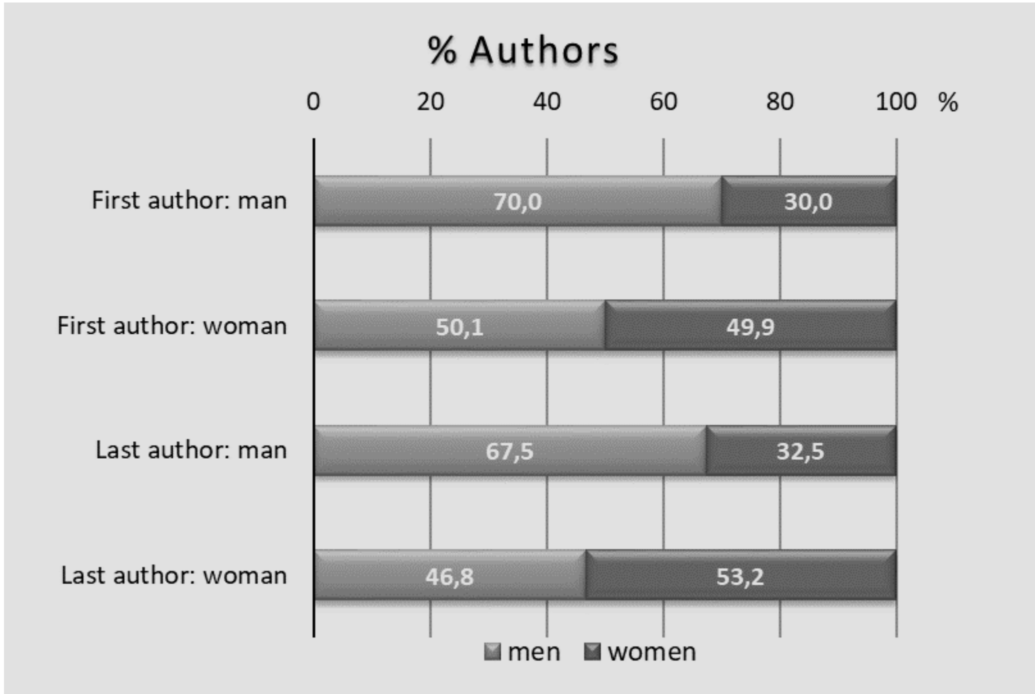

Figure 2. Percentages of authors (men and women) depending on which gender occupied the first or last/senior positions in the article byline. Values were calculated for articles with at least three co-authors.