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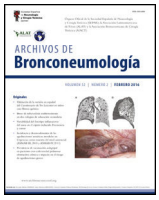

Original Article

Gender differences in original *Archivos de Bronconeumología* publications, 2001-2018☆

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ABSTRACT

Introduction: Gender inequality exists in scientific publications. The aim of this study was to determine changing patterns in gender differences and factors associated with the positioning of authors' names in original articles published in Archivos de Bronconeumología (AB).
Methods: We performed a bibliometric study of articles published in AB between 2001 and 2018. Author gender was analyzed in four scenarios: first author, last author, middle authors, and mentee authors. Comparisons were made by authors' specialties, funding received, multicenter studies, specialist areas, and others. Multivariate models adjusted for the percentage of registered physicians in the Spanish health system were created to predict the female gender of the first, middle, and last author.
Results: A total of 828 publications were analyzed in which women appeared as first authors in 286 (34.5%) and last authors in 169 (20.4%). A gradual increase in women as first authors was observed ($p = 0.0001$), but not as last authors ($p = 0.570$). Overall, the average number of female authors increased over time (from 1.6 ± 1.4 in 2001–2005 to 3.3 ± 2.3 in 2016–2018, $p = 0.0001$), with no differences in male averages. The adjusted multivariate models reflected a positive bi-directional relationship between the first author and the middle authors, and a negative association between the first author being Spanish and the last author being female (OR 0.57; 95% CI 0.36–0.88, $p = 0.012$).
Conclusions: Gender differences were found in various aspects of authorship in AB, summarized by a greater participation of women as first and intermediate authors, but not as last authors.

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Diferencias de género en las publicaciones originales de ARCHIVOS DE BRONCONEUMOLOGÍA en el periodo 2001–2018

Palabras clave:
Género
Análisis bibliométrico
Publicaciones

RESUMEN

Introducción: La desigualdad de género existe en las publicaciones científicas. El objetivo del estudio fue determinar la evolución histórica de las diferencias de género y factores asociados a las posiciones de las autorías de los trabajos originales de Archivos de Bronconeumología (AB).
Métodos: Estudio bibliométrico de AB en el periodo 2001–2018. Se analizó el género de las autorías en cuatro escenarios: primera firma, última firma, autorías intermedias y mentorizadas. Se realizaron comparaciones por especialidad firmante, financiación recibida, carácter multicéntirico y área temática, entre otras. Se crearon modelos multivariantes ajustados por el porcentaje de médicas colegiadas en el sistema sanitario español para predecir el género femenino de la primera, intermedia y última firma.
Resultados: Se analizaron 828 publicaciones, donde las mujeres figuraron como primeras autoras en 286 (34,5%) y como últimas en 169 (20,4%). Se observó un incremento gradual de mujeres como primeras autoras (p = 0,0001), pero no como últimas firmantes (p = 0,570). En general la media de autoras mujeres aumentó con el tiempo (1,6 ± 1,4 en 2001-2005 a 3,3 ± 2,3 en 2016-2018, p = 0,0001), sin apreciarse diferencias en las medias de hombres. Los modelos multivariantes ajustados reflejaron una relación bidireccional positiva entre la primera autoría y las intermedias, y una asociación negativa entre que el primer autor haya sido español con una última autoría femenina (OR 0,57; IC95% 0,36-0,88, p = 0,012).
Conclusiones: Se encontraron diferencias de género en varios aspectos de las autorías de AB, resumidas en una mayor participación de las mujeres como primeras firmantes e intermedias, pero no como últimas autoras.

Introduction

The 21 st century has witnessed an interesting and long overdue move towards gender equality, and scientific publications are no exception. In recent years, numerous journals have published their results in this area,[1–4] and except for some differences, they all come to similar conclusions: women are participating more as time goes on, but there is room for improvement. This situation is particularly acute when it comes to the last signature on the article, which tends to be attributed to the research coordinator.[5] Recent studies conclude that gender bias is the most important factor, while others have shown that gender inequalities mean that women are less likely to be hired or promoted.[6–8]

In respiratory medicine, recent reports suggest that less than one third of first authors in critical care and less than 25% of last authors (i.e., in a senior position) are women, and these figures have increased only minimally in the last decade.[9] However, results also show that when the last author is a woman, the probability of the first author being a woman is higher, although such studies tend to be published in journals with a lower impact factor (IF).[9] The *European Respiratory Society* has also highlighted the limited participation of women in prestigious positions at its conferences.[10,11] *Archivos de Bronconeumologia* (AB), the flagship journal of the Spanish Society of Pulmonology and Thoracic Surgery (SEPAR) and the Latin American Thoracic Association (ALAT), is the Spanish language respiratory journal with the greatest worldwide impact. Its IF places it in the first quartile of the *Journal of Citation Reports* lists, according to the 2018 edition, so an analysis of gender differences in its publications is warranted. The aim of this study was to determine trends and changing patterns in gender differences over time and factors associated with the positioning of authors' names in original articles.

Methodology

Description

We performed a bibliometric study of original articles (as these were considered the most representative type of document) published in AB between 2001 and 2018. This period was selected to include AB's transition from a journal with no IF to its inclusion in the list of top quartile journals, and could also be easily divided into sub-periods (2001–2005, 2006–2010, 2011–2015, and 2016–2018). All study authors were retrieved manually, and the gender of the first and last authors together with the number and gender of authors in middle positions were documented after 22 manuscripts signed by 1 or 2 authors had been excluded. Citations were collected on December 23, 2019 from the *Science Citation Index Expanded (SCI-E)* database, owned by *Clarivate Analytics*®.

The following variables were also collected manually: autonomous community and country of origin of the first author; specialty or discipline of all authors (according to the Specialties in Health Sciences Training Programs of the Ministry of Health, Consumer Affairs, and Social Welfare)[12]; therapeutic area as defined by the Spanish Society of Pulmonology and Thoracic Surgery (SEPAR); number of institutions, specialties, and countries participating; declaration of funding; and the time between receipt and approval of the manuscript. As indicators of gender differences among professionals, the annual percentage of female Spanish doctors during the study period was collected from Organization of Medical Societies and National Institute of Statistics data.[13,14]

Statistics

Version 20 of the Statistical Package for the Social Sciences® program (SPSS, Chicago, IL, USA) was used for the statistical analysis. Qualitative variables are presented as absolute numbers and percentages, and quantitative variables as mean ± standard deviations. The difference between dichotomous variables was analyzed using the Chi-square test. The normal distribution of quantitative variables was evaluated by the Kolmogorov-Smirnov test. As the data did not follow a normal distribution, the Mann-Whitney U or Kruskal-Wallis tests were used for comparison of two or more independent samples, respectively. Three multivariate logistic regression models were used: one to predict that the first author would be a woman, another that the last author would be a woman, and a third to predict a predominance of women in middle positions (> 50% women authors in those positions). For the construction of the adjusted multivariate models, variables that were significant in the crude bivariate analyses and the annual percentage of women

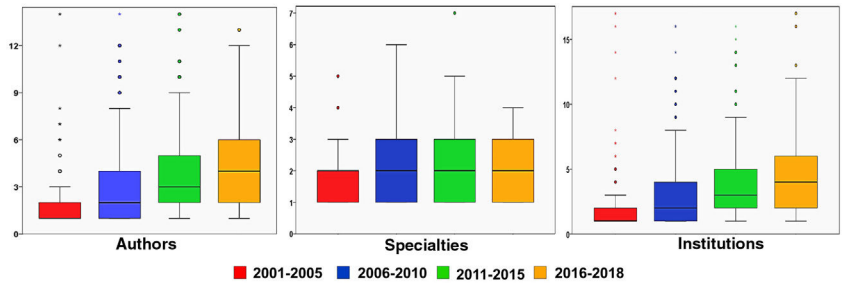

Fig. 1. Mean numbers of authors, specialties, and institutions participating in original *Archivos de Bronconeumología* publications over the study periods. Kruskal-Wallis test < 0.05 in all categories.

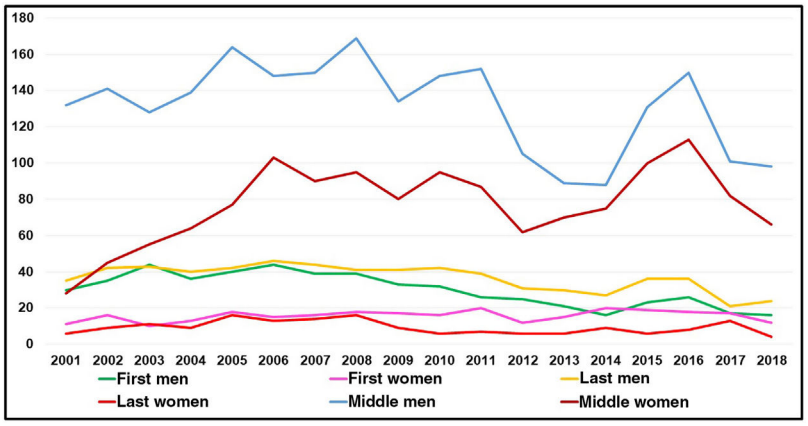

Fig. 2. Gender trends among first, last and middle authors of original articles published in *Archivos de Bronconeumología* in the period 2001-2018.

enrolled as physicians in Spain were included. The goodness of fit of the models was assessed by the Hosmer and Lemeshow test. In line with the proposals of other authors,[8,11] gender "mentorship" was also evaluated, i.e. when first and last authors were of the same gender.

Results

A total of 828 articles were included in the study. The average number of authors per article was 6.5 ± 2.5; institutions 3.1 ± 2.9; specialties 2.0 ± 0.9; and countries 1.1 ± 0.6. Fig. 1 shows trends in these numbers over time, revealing a significant increase in all of these elements. Respiratory medicine was the most productive specialty or discipline with 523 papers (63.2%), and Spain was the country which produced the most publications (693, 83.7%). The most productive Autonomous Community was Catalonia with 192 publications (27.7% of the Spanish contribution and 23.2% of the total), followed by the Valencian Community with 105 publications (15.2% of the Spanish contribution and 12.7% of the total), and the Madrid Community with 102 (14.7% and 12.3%, respectively). Overall, 299 studies (36.1%) received funding, and the most productive area was chronic obstructive pulmonary disease, with 141 articles (17%).

In terms of authorship gender, women appeared as first authors in 286 (34.5%) and as last authors in 169 (20.4%) articles. More men than women appeared among the total number of authors in 560 publications (67.6%), more women than men in 168 (20.3%), while parity was observed in 100 (12.1%). No female authors appeared in 112 studies (13.5%), and no men participated in 10 (1.2%). Of the 806 articles with more than two authors, 163 did not include women as middle co-authors (20.2%), and 57 did not include men (7.1%). Women were predominant among the number of middle co-authors in only 328 publications (40.7%) In general, the number

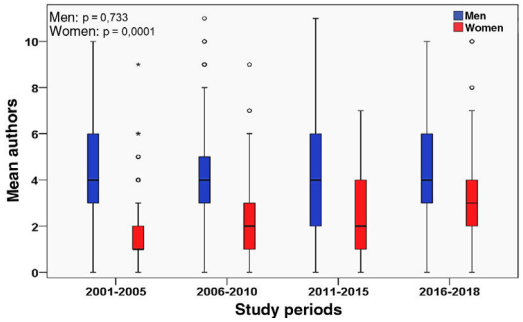

Fig. 3. Mean number of authors by gender in original articles published in *Archivos de Bronconeumología*.

of female middle authors was lower than that of males (2.3 ± 1.8 vs. 4.2 ± 2.2; p = 0.0001). Fig. 2 shows the yearly trend of absolute numbers of men and women as the first, middle or last authors during the study period.

A gradual increase was detected in women as first authors over the study time periods, but not as last authors (Table 1). A significant increase was also observed in the mean number of female authors (Fig. 3), except when comparing the periods 2006–2010 and 2011–2015. The greatest difference was observed between 2001–2005 and 2016–2018, with an increase of 1.6 ± 1.4–3.3 ± 2.3 women authors per article (p = 0.0001). In contrast, there were no differences in mean numbers of men authors among the different periods evaluated. Fig. 4 shows annual trends in the number of registered doctors in Spain according to gender.

Throughout the entire study period, the mean number of middle female authors was lower than that of males (2.6 ± 1.8 vs. 3.0 ± 2.1; p = 0.0001). However, when the first author was a woman, the number of female middle authors exceeded that of men (2.0 ± 1.6

Table 1
Gender of first and last authors of original articles in *Archivos de Bronconeumología* over the study periods.

Study period	First author		Last author		Total
	Men	Women	Men	Women	
2001–2005	185 (73.1)	68 (26.9)	202 (79.8)	51 (20.2)	253
2006–2010	187 (68.8)	85 (31.2)	214 (78.7)	58 (21.3)	272
2011–2015	111 (56.3)	86 (43.7)	163 (82.7)	34 (17.3)	197
2016–2018	59 (55.7)	47 (44.3)	81 (76.4)	25 (23.6)	106
p-value	0.0001		0.570		828

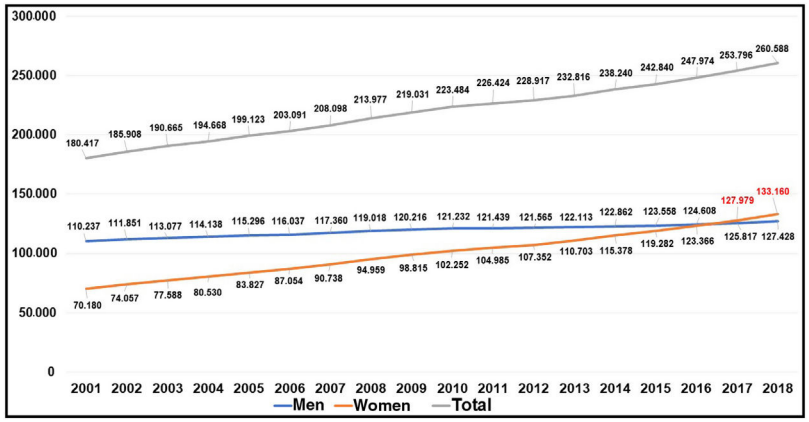

Fig. 4. Annual trends in number of registered doctors in Spain by gender. Numbers of women after outnumbering men in 2017 shown in red.

vs. 1.5 ± 1.4; p = 0.003). With regard to mentorship, no differences were found in gender rates of the first and last authors (p = 0.856), so that when the last author was a man, the first author was also a man in 433 articles (65.6% of the publications whose last author was male), while when the last author was a woman, the first author was a man in 109 publications (64.9% of the articles whose last author was a woman).

Pediatric pulmonology was the area with the highest number of women authors (3.0 ± 1.8), whereas the lowest mean number was found in thoracic surgery (1.4 ± 1.3) (Fig. 5). Differences among areas were also found in the number of male authors, ranging from lower values in nursing (1.0 ± 0.1) to higher values in interstitial diseases (5.3 ± 1.7; p = 0.0001). In terms of funding, 113 of the 286 (39.5%) articles with female first authors received funding, compared to 186 of the 542 articles (34.3%) with a male first author (p = 0.149). No gender differences were found according to the authors' specialty or the multicenter character of the manuscripts evaluated (Table 2). Nor were differences identified in the number of citations received among publications signed by women or by men as first author (10.8 ± 10.5 vs. 10.9 ± 10.4; p = 0.507) or as last author (11.4 ± 11.4 vs. 10.7 ± 10.2; p = 0.697). No differences were found in time to acceptance of manuscripts between first female and first male authors (114 [interquartile range 103.3–124.27] vs. 120 [113.8–126.2] days; p = 0.10).

Finally, determinants of the presence of a first female author selected by logistic regression models were the percentage of women doctors in Spain and the number of women in middle authorship positions. However, in the multivariate analysis, only the number of women in positions of middle authorship was retained as an independent associated factor (Table 3).

With regard to the predominance of women in middle co-authorship positions, an inverse correlation was found with the number of institutions participating in the publication and with multicenter studies, whereas women were more predominant when the first or last author was a woman or when the percentage of women doctors in Spain was higher than that of men (Table 4). However, the multivariate analysis only retained a smaller number of participating institutions and the first author being a woman as independent predictors of the predominance of women in middle co-authorship positions. It is notable that publications from Spanish hospitals featured fewer women as last authors, in both the crude and adjusted analyses (Table 5).

Discussion

The most important finding of this study is that gender differences were revealed in various aspects of authorship in AB, summarized by a greater participation of women as first and middle authors, but not as last authors.

Gender differences are a recurring theme in bibliometric analyses, be they old,[15,16] recent,[2–7,9,10] national,[17–19] or international.[20,21] However, this information may have gained considerable importance in this century, given the recent movements in favor of equal rights and other sociological aspects that go beyond the scope of this study, which reports the trends observed in a scientific journal that has undergone significant changes. This study addresses factors associated with the position of female authorship in four scenarios: first author, last author, middle authors, and mentee authors. However, despite the results obtained from the analyses, each scenario is complex. For example, the gender of last authors did not undergo any significant change during the study period, and the only associated variable was the country of origin of the article, which suggests that international publications are more likely to be coordinated by a woman than Spanish publications. Our immediate reaction is that gender differences in Spain must be more polarized to the detriment of women in senior positions, but honorary authorship and even occasionally authorship by coercion from section heads and coordinators, is manifest in scientific publications, and the more men in charge, inevitably the more men will appear as last authors.[22,23] However, a positive bidirectional relationship was detected between first authors and middle authors. Both positions are dependent on the percentage of registered women doctors, while the number of middle female authors is affected negatively, although to a lesser extent, by the

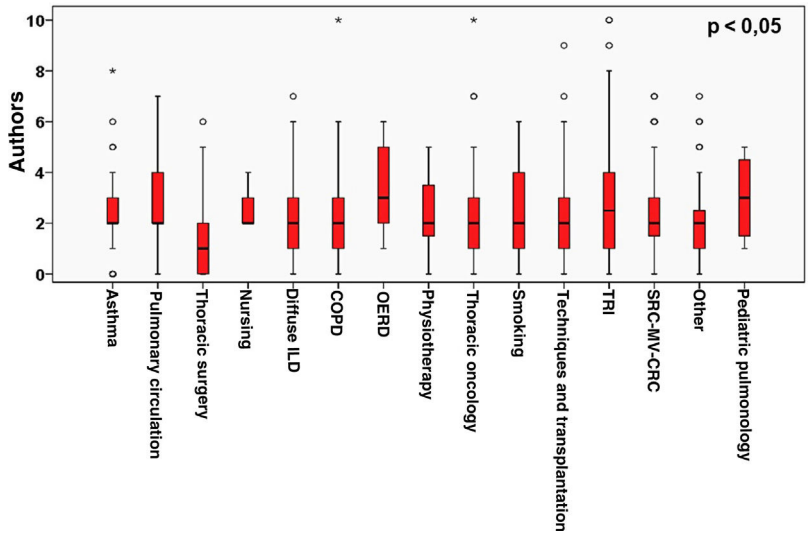

Fig. 5. Average number of authors by SEPAR therapeutic areas.
COPD: chronic obstructive pulmonary disease; ILD: interstitial lung diseases; OERD: occupational and environmental respiratory diseases; SEPAR: Spanish Society of Pulmonology and Thoracic Surgery; SRC-MV-CRC: sleep respiratory disorders-mechanical ventilation-critical respiratory care; TRI: tuberculosis and respiratory infections. Kruskal-Wallis test.

Table 2
Comparison of gender of first and last authors based on specialty, funding, and type of collaboration.

Category	First author		Last author	
	Women	Men	Women	Men
Specialty				
Pulmonology	186 (22.5)	337 (40.6)	106 (12.8)	417 (50.4)
Other	100 (12.1)	205 (24.8)	62 (7.5)	243 (29.3)
p-value	0.45		0.99	
Funding				
Yes	113 (13.6)	186 (22.5)	57 (6.9)	242 (29.2)
No	173 (20.9)	356 (43.0)	111 (13.4)	418 (50.5)
p-value	0.15		0.53	
Collaboration				
Single-center	100 (12.1)	190 (22.9)	53 (6.4)	237 (28.6)
Multicenter	186 (22.5)	352 (42.5)	115 (13.9)	423 (51.1)
p-value	0.99		0.32	

Table 3
Bivariate and multivariate logistic regression model adjusted to predict the probability of a woman as first author.

Unadjusted model			
Variable	OR	95% CI	p-value
Number of institutions	0.964	0.916–1.015	0.168
Multicenter study	0.996	0.738–1.345	0.979
Number of specialties	1.024	0.876–1.196	0.770
First author pulmonologist	1.131	0.839–1.525	0.418
Number of countries	1.073	0.834–1.379	0.585
First author Spanish	0.986	0.669–1.452	0.942
Publication funded	1.250	0.930–1.681	0.139
Last author female	0.541	0.679–1.382	0.751
Percentage of women doctors	1.098	1.053–1.145	0.0001
Predominance of women as middle authors	1.668	1.244–2.237	0.0001
Adjusted multivariate model[a]			
Predominance of women as middle authors	1.540	1.143–2.076	0.005

[a] Adjusted by percentage of women doctors.

number of participating institutions. But in what order do these factors occur and why? Does the first author choose the other co-authors regardless of their gender or, if there are more women in the field, is there a greater likelihood of one becoming first or middle author? All these factors are probably at play, but it seems logical that the first author decides with whom to publish, although the reasons for this decision are unfortunately not reflected in any study of this type. Competence? Rapport? Gender bias? Aside from these possibilities, we found that the mean numbers and probability of the gender of middle authors depends on the gender of the first author, so our observations cannot be limited to the fact that more women are publishing than 30 or 40 years ago. To com-

Table 4
Crude bivariate and multivariate logistic regression model adjusted to predict the probability of predominance of women as middle authors.

Unadjusted model			
Variable	OR	95% CI	p-value
Number of institutions	0.913	0.865– 0.964	0.001
Multicenter study	0.699	0.521– 0.938	0.017
Number of specialties	0.885	0.757–1.034	0.123
First author pulmonologist	0.995	0.743–1.332	0.972
Number of countries	0.744	0.537–1.030	0.075
First author Spanish	0.847	0.578–1.242	0.396
Publication funded	0.799	0.596–1.072	0.135
First author female	1.668	1.244–2.237	0.001
Percentage of women doctors	1.093	1.049–1.139	0.0001
Last author female	0.664	1.329–1.664	0.032
Adjusted multivariate model[a]			
Number of institutions	0.897	0.837– 0.961	0.002
Multicenter study	0.732	0.504–1.064	0.102
First author female	1.451	1.071–1.967	0.016

[a] Adjusted for percentage of women doctors.

Table 5
Crude bivariate and multivariate logistic regression model adjusted to predict the probability of a woman as last author.

Unadjusted model			
Variable	OR	95% CI	p-value
Number of institutions	0.991	0.934–1.051	0.769
Multicenter study	1.216	0.846–1.746	0.290
Number of specialties	0.991	0.934–1.051	0.769
First author pulmonologist	1.004	0.707–1.426	0.983
Number of countries	1.161	0.888–1.517	0.276
First author Spanish	0.563	0.370–0.856	0.007
Publication funded	0.887	0.621–1.267	0.510
First author female	1.032	0.724–1.473	0.860
Percentage of women doctors	1.003	0.956–1.054	0.893
Predominance of women as middle authors	0.851	0.601–1.206	0.364
Adjusted multivariate model[a]			
First author Spanish	0.568	0.365–0.884	0.012

[a] Adjusted for percentage of women doctors.

plete this section, no association with mentorship and gender was found, unlike other similar studies,[5,9] or the results of a recent study of hepatology publications between 2014 and 2016 that included 2132 articles. The latter study reported that when the last author of an article was a woman, 52.9% per cent of the first authors were women and 47.1% were men, whereas when the last author was a man, 32.9% of the first authors were women and 67.1% were men.[24]

Partial similarities have been found with respect to the growing participation of first authors in radiology journals and others with a high IF.[21,25] In these cases, it should be noted that AB achieved similar proportions in a shorter period of time than the cited studies, which analyzed a period of 35 years. There was no direct comparator in the respiratory area, but fortunately the *American Journal of Critical and Respiratory Care Medicine* and the *European Respiratory Journal*, two of the most consulted first-quartile respiratory journals, recently published findings that were in line with ours: the number of women authors is increasing, but not the number of women coordinating authors. The feminization of the medical and health profession in general is undeniable, and the changes in Spain have been substantial. In 1954, there were 3 female registered doctors, almost 20,000 up to 1982, and in 2017, female doctors (127,464) surpassed men for the first time (126,231). Data trends in recent years point to noteworthy changes in the proportion of men and women becoming registered as doctors: between 2011 and 2017, 5 times more women were registered than men (4999 men and 25,212 women). This has eliminated a gender gap that was greater than 39% in 1990 and 7.3% in 2011.[13,14,26] If this situation is extrapolated to Spanish respiratory medicine, women specialists outnumbered their male counterparts, at least in terms of SEPAR membership, 2 years before they outnumbered male doctors in general (Fig. 6).[27]

Despite the manifest feminization of general and respiratory medicine, we believe it is important to emphasize once more that little has changed in terms of women coordinating authors. In addition to the studies already cited,[4,5,7,9,10] very similar results were found in an analysis of publications on hepatopancreaticobiliary surgery, which reported a non-significant increase from 7.1% to 10.1% in last authors and, interestingly, a greater likelihood that women would appear as last authors in journals in the middle of the IF table of specialist journals in the field.[28] In our case, the impact of the articles, measured by conventional citation ratings (often misinterpreted as a quality rating), was similar regardless of the gender of their first or last authors. With respect to other important factors relating to the publication of an article, such as funding and acceptance time, no significant gender differences were observed. However, it is important to note that in longer studies, such as the *Journal of Cardiothoracic and Vascular Anesthesia* study that encompassed 1990–2017, the difference in last authors can be statistically significant: the cited article reports an increase from 7% in the period 1992–1995 to 11.5% in 2015-2017.[29] Despite these methodological considerations, the presence of women as last authors is still far from equal, and there is much work to do. In terms of therapeutic areas, thoracic surgery unsurprisingly has the lowest mean number of women, given that gender differences are more marked in favor of men in surgical areas - a difference that extends, worryingly, to the remuneration received for doing the same work.[30–32]

Strengths and limitations

As far as we know, this study is the first analysis to be carried out on the subject in a Spanish biomedical journal in more than 10 years. It covers a longer period than others,[17–19] and features more complex statistics, with the inclusion of multivariate models. Moreover, gender differences in the number of registered doctors were taken into account, in line with other very recent studies published in high-IF journals.[4,5,9] These 3 strengths may be useful not only to the AB editorial team but also to the editors of other journals, readers, and the general public in their efforts to promote gender equality.

Our study naturally has limitations, one of which was the elimination of any document type other than original articles. We believe that original articles are sufficiently representative and, moreover, the results probably would have been similar if other article types had been examined, as recently demonstrated in a study of 2459 medical journals in which women were 21% less likely to be invited to write editorials, despite having the same experience as men.[33] Another limitation is that other variables may be associated with differences that were observed but not analyzed: author age, for example, springs to mind. In line with an article published in January 2020 in *National Geographic,* a serious, informative journal with worldwide readership, we believe that balancing work and family duties takes a greater toll on women and possibly impacts negatively on their scientific production in their childbearing years and beyond.[34]

Conclusions

Gender inequality is a current social problem to which scientific publications are not immune. In this study, we found that women are appearing more than before as both first and middle authors, in the context of the feminization of the profession. However, there is considerable room for improvement in their position as coordinating author. The scenario is complex, and these differences may also be influenced by sociological factors that remain unclear, but we hope that this study will raise sufficient awareness to prompt more in-depth analysis of the situation in future studies.

Authors' contribution

Daniel López-Padilla participated in data collection and is responsible for the integrity and accuracy of the analysis. He also contributed to the study design, interpretation, analysis and drafting of the final document. Marta Pérez-Gallán contributed to data collection, interpretation and drafting of the final document. Nuria Arenas Valls, Alicia Cerezo Lajas, Marta Corral Blanco, Virginia Gallo González, Milagros Llanos Flores, María Martínez Redondo, Natalia Martos Gisbert, Elena Ojeda Castillejo, Marta Padilla Bernáldez, Vania Prudencio Ribera, Luis Puente Maestu, Beatriz Recio Moreno, Elena Rodríguez Jimeno, Ana Sánchez Azofra, Gonzalo Segrelles-Calvo, José Terán Tinedo, and Perla Valenzuela Reyes contributed to the interpretation and drafting of the final document. Francisco García-Río, Adolfo Alonso-Arroyo, and José Ignacio de Granda-Orive contributed substantially to the study design, interpretation, analysis, and drafting of the final document.

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Conflict of interests

The authors state that they have no conflict of interests.

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