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Laboratory Investigation

LABORATORY INVESTIGATION

Gender differences in professional social media use among anaesthesia researchers

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Abstract

Background: Recent studies suggest that female researchers are less visible on social media. The objective of this observational work was to compare the use of professional social networks between male and female anaesthesia researchers.

Methods: Among four anaesthesia journals, we analysed the first/last authors (FA/LA) of the most frequently cited articles in 2016–2017 and the authors who published more than one article per year between 2013 and 2018 (prolific authors). We compared the use of the professional social networks Twitter, LinkedIn, and ResearchGate by the selected authors and analysed the proportion of women in FA and LA position. The variables are presented as median (interquartile range).

Results: The analysis included 260 FA, 232 LA, and 297 prolific authors. Despite similar declared skills and number of citations, women had lower scientific reputation scores on ResearchGate (RG score: 32.0 [24.4–41.1] *vs* 20.3 [15.1–29.2]; $P<0.0001$ in the FA group; 39.3 [34.3–43.4] *vs* 35.7 [30.3–39.5], $P<0.01$ in the LA group; and 41.5 [35.6–45.7] *vs* 36.8 [28.1–42.7], $P<0.01$ in the prolific group). In all groups, women were significantly less followed on ResearchGate than men. In the three groups, the Twitter (22.7%, 25.0%, and 23.6%, respectively) and LinkedIn (59.2%, 56.5%, and 62.3%, respectively) usage rate were similar with no difference between men and women in each group. Of the 260 articles included, 94 (36.2%) manuscripts had female FA, whereas 41 (15.8%) had female LA.

Conclusion: In anaesthesia, the visibility of female researchers on the social network dedicated to scientific research is lower than that of male researchers.

Keywords: anaesthesia; authorship; gender; media; publications; scientific research; sex; social media; women

Editor's key points

- Professional social networks are important in the outreach of scientific publications.
- This study investigated the use of social networks among women and men anaesthesia researchers.
- Women have a lower visibility on social networks dedicated to scientific research than men in anaesthesia journals.
- The use of social networks could be an interesting tool in the empowerment of women scientists in anaesthesia research.

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Women represent the majority of newly trained medical doctors, and the position of women in medical research is increasing.[1] In anaesthesia, despite encouraging data showing an increase in the number of women in academic positions, they are still under-represented in research in view of the global sex ratio of medical doctors.[2]

Social networks have now taken a major place in the scientific field and are essential tools for promoting research and researchers (including the recruitment or the promotion of a researcher).[3–5] Among participants in a recent medical congress, women were significantly less visible on Twitter than their male colleagues (despite similar degrees, position, and Twitter use).[6] Despite the fact that women represented 53% of the participants at this congress, their real visibility on the Internet remains far below that of their male counterparts. The proportion of women as first (FA) or last authors (LA) is increasing in anaesthesia research articles.[2] It is estimated that about 22% of LA positions and 30% of FA positions are occupied by women.[2] However, these data do not take into account the impact of the studies published. Moreover, there is no published work on the visibility of female researchers in anaesthesia on social media.

In order to better estimate the overall visibility of female researchers in anaesthesia, we focused on the researchers most visible to the medical community: FA/LA of the most cited articles and the most prolific authors in terms of number of anaesthesiology publications. The objective of this work was to determine the presence of female anaesthesia researchers on professional social networks and to compare it with that of male anaesthesia researchers.

Methods

Population selection

We used publicly available data for this work. As a retrospective bibliometric analysis that did not involve human subjects, this study was exempt from institutional review board review. This work focused on the authors of original and review articles (exclusion of guidelines and expert recommendations, letters to the editor, case reports, book chapters, etc.). The results are reported in accordance with the Strengthening the Reporting of OBservational studies in Epidemiology (STROBE) statement.[7]

The main objective of this work was to determine, among the population of FA and LA of the most cited articles, the presence of women on professional social networks (primary endpoint). The secondary objectives were to:

- Describe women proportion in FA/LA positions in the most frequently cited articles.
- Determine, among the population of the most active authors ('prolific' authors), the proportion of women in professional social media networks.

This study was thus carried out in two parts. The first part was an analysis of the FA and LA of the most frequently cited articles in the 2016–2017 period (determining the 2018 Impact Factor). The inclusion criteria for the journals from which the analysed articles were obtained were:

- Journals dedicated to all areas of anaesthesia
- Journals listed in the top quarter of the 'ANESTHESIOLOGY' category in the 2018 Journal of Citation Reports (JCR) classification (i.e. the first eight places of the ranking)[8]

The journals were excluded if the sex of the authors was not identifiable (absence of first name in the article). In the journals included, the most cited articles analysed were defined as those cited more frequently than the maximum Impact Factor of the 'ANESTHESIOLOGY' category of the 2018 JCR (i.e. at least seven citations in 2016–2017).[8]

The second part was an analysis of the most prolific authors. Among the journals selected in the first part, we focused on the so-called 'prolific' authors over the past 6 yr (i.e. publishing on average more than one article per year: at least seven publications in these journals over the 2013–2018 period). To identify the authors, we queried the Web of Science Database for the considered journals separately using their respective International Standard Serial Number (ISSN). We restricted the results to the period 2013–2018 and to the document types 'article' and 'review'. The lists of most productive authors for each journal were retrieved through the results analysis tool provided by the database. The list obtained only gave the surname and initials of the first name, the full first name was found on the sites of the studied journals.

Population analysis

Once the two lists of authors were established, we first determined their sex. Author sex was determined based on the first name. If the gender of the name was unclear, attempts were made to elucidate the sex using search engines (e.g. Google Image) and institutional website profiles. If the sex of the FA, LA, or both remained indeterminate after this search, the article and its authors were excluded. If there was only one author, that person was considered as the FA only.

In a second step, we analysed the presence of included researchers on professional social networks: Twitter (professional account), ResearchGate, and LinkedIn. The screening and analysis procedure for finding social network accounts was as follows:

- The first and last name (with and without the initials of the middle name) was entered into the social network search engine. On Twitter, the author was searched on the account search tool but also on the 'TOP' and 'LATEST' tab.
- If no author was found after this first search, only the last name was used in association with the following keywords: 'M.D.', 'Dr', 'Anesthesia', 'Anesthesiology', '[Name of the researcher's hospital/university]'.
- If several accounts were found for a given name, all accounts were manually analysed in search of information on the account, to identify whether or not it was the researcher's account (particularly through her/his hospital, academic affiliation, or both).
- If an author had several accounts on a social network, the account with the most activities/followers/referencing was considered.

We compared men and women, and the following data were collected:

- For Twitter, existence of an active 'professional' Twitter profile (at least one professional tweet on a Twitter account); if active account, number of tweets, number of people followed, and number of followers.
- For ResearchGate, existence of an active ResearchGate profile (with a least one research work documented); if existing profile: presence or not of a photograph, number of people followed and number of followers, number of skills/

expertise, RG score (which is a measure of scientific reputation on ResearchGate), and Total Research Interest score (which is linked to the reading, citation, and recommendation of the researcher's work on ResearchGate); information's of ResearchGate on its own scores can be found at the following internet addresses: https://explore.researchgate.net/display/support/RG+Score and https://explore.researchgate.net/display/support/Research+Interest;

- For LinkedIn, existence of a LinkedIn profile (and if existing profile: number of contacts, presence or not of a photograph). On LinkedIn, the precise number of contacts is no longer indicated above 500. We therefore compared the proportion of LinkedIn subscribers with more than 500 contacts and, for those with less than 500 contacts, the exact number of contacts.

Statistical analysis

The values are presented as number and percentage (*n*, %) for qualitative variables, and as median (inter-quartile range) for quantitative variables. After performing D'Agostino–Pearson normality tests, we found that the distributions of the data analysed were not normal and the quantitative variables were compared using a Mann–Whitney test. The qualitative variables were analysed using a χ^2 test or a Fisher's exact test if there were few observations (less than 15 for individual cells). Tests were two-sided, and the significance threshold was set at 0.05, all statistics were produced using GraphPad PRISM software (v 5.0; GraphPad Software Inc., San Jose, CA, USA).

Results

To limit the impact of profile variations on social networks on our data, the entire data collection was carried out manually over a brief period of 10 consecutive days in October 2019.

Analysis of the first/last authors of the most frequently cited articles

Among the eight journals ranked in the top 25% anaesthesia journals in the 2018 JCR, four met our inclusion criteria (*Anesthesiology*, *Anesthesia and Analgesia*, *European Journal of Anaesthesiology*, and *Journal of Clinical Anesthesia*), 260 articles were analysed (204 original articles and 56 reviews; cf. Fig. 1). Four journals were excluded: two because of the impossibility to determine the sex of the authors given the absence of author's first name (*British Journal of Anaesthesia* and *Anaesthesia*) and two that were only dedicated to a specialised field of anaesthesia (*Pain* and *Regional Anesthesia and Pain Medicine*; cf. Fig. 1). Among the 260 manuscripts analysed, there were only five articles for which there was only one author and 260 FA and 255 LA were identified, five researchers (four men, one woman) were present in both the FA and LA lists (for different works) and six researchers (five men, one woman) were present in the FA list, the LA list and the prolific authors list. As some authors were found several times in the LA position for different articles, 23 LA redundancies were eliminated for a total number of 232 independent LA analysed for social media use. All data concerning professional social media use of FA and LA are presented in Tables 1 and 2.

Analysis of the proportion of women in first/last author positions

Overall, 94 (36.2%) manuscripts had female FA, whereas 41 (15.8%) had female LA. Among the articles analysed, 147 (56.5%) were from studies carried out by a North American team (USA or Canada) *vs* 113 (43.5%) carried out by a team from another continent or by a North America/other continent collaboration. The rates of female FA and LA by publication type were similar: 74 (36.3%) and 30 (14.7%) women as FA and LA for original articles, and 20 (35.7%) and 11 (19.6%) for reviews, respectively (P=0.51).

Analysis of the most prolific authors

In the four journals included in the first part, 335 authors meeting our definition of prolific authors for the 2013–2018 period were found. Among them, 38 were excluded (three with non-determinable sex and 35 with homonyms) and 297 were finally analysed (249 men and 48 women). All data concerning professional social media use are presented in Table 3. Of the 297 authors, 26 (22 men and four women) were present in both the FA and prolific authors lists and 40 (37 men and three women) were present in both the LA and prolific authors lists.

Discussion

This article describes the participation rates and use patterns of professional social networks among anaesthesia researchers. We show that, despite a similar rate of use of most of these networks by women, their visibility remains lower than that of their male counterparts, particularly on the social network dedicated specifically to scientific research (ResearchGate). We also show that the proportion of women in FA/LA positions among the most frequently cited articles are similar to the rates previously described for all articles published in 2017 in two anaesthesia journals.[2]

Our data support the fact that there does not seem to be any variation in the sex ratio of authors according to the scientific impact of their work (highly cited articles). However, despite a gradual increase in the number of women in anaesthesia publications, they still represent only 16% of 'prolific' authors. This rate probably corresponds to the rate of female 'senior' authors involved in several published studies (as shown by the similar rate of LA women in our work). This low rate of female senior authors is most probably because senior researchers remain predominantly male and that the feminisation of the profession has not yet affected this age group. There is a historical gender imbalance in medical doctors and, owing to the latency of reaching senior author status, it will take time before the rate of senior authors is reflective of the global rate of women in medicine. But given the current global feminisation of anaesthesia research, it is very likely that this rate will continue to increase in the coming years.[2]

We studied the use of professional social networks by anaesthesia researchers through two approaches: analysis of the first and last authors of highly cited works over a short period, and analysis of the authors frequently contributing to publications over a longer period. As prolific authors are often in intermediate position among all authors, these two approaches seemed complementary in order to have many researcher profiles: first/main author (sometimes junior author), senior author, and investigator/collaborator. This choice made the study population heterogeneous but meant it

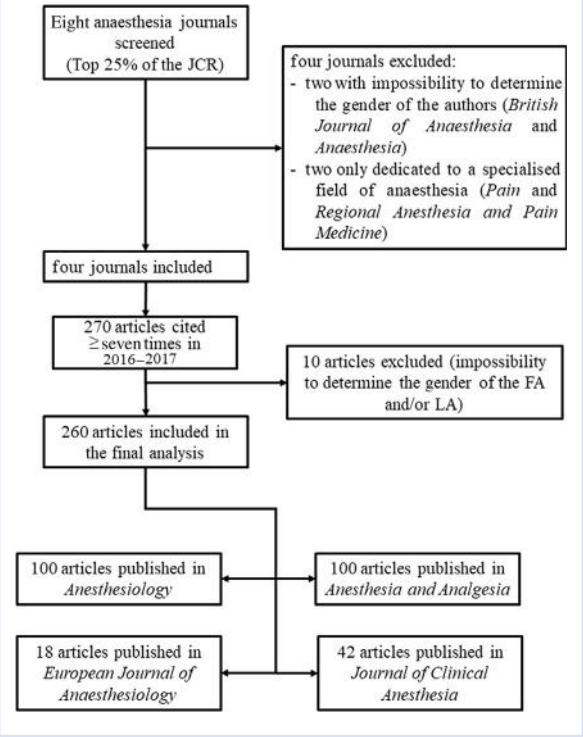

Fig 1. Flowchart of journal and article selection. FA, first author; JCR, Journal of Citations Report; LA, last author.

was not possible to forget one particular type of researcher. Of course, some researchers may move from one role to another (e.g. FA on one work and LA on another) or cumulate several (e.g. being prolific and LA on the same period), but the maximum recovery rate between our authors' lists was about 17% (between LA and prolific lists), showing that these three populations were relatively distinct. The rate of use of the social media appeared similar in the three categories studied. FA are sometimes junior researchers and are therefore probably, on average, younger than the LA population (who are always senior researchers). It is interesting to note that FA (who we assume are, on average, younger than other groups of authors) do not have a higher utilisation rate of social media than LA. In the population studied, the rates of use of professional social networks (Twitter, 20–25%; ResearchGate, 60–70%; and LinkedIn, 55–60%) are higher than those recently described among ENT surgeons, neurosurgeons, or paediatric orthopaedists (Twitter, 2–13%; ResearchGate, 23–36%; and LinkedIn, 37–55%).[9–11] The fact that we only included high-level scientific authors in our analysis, *vs* members of a surgical society in these other works, probably explains this difference.

The three social networks analysed here have different uses in professional life. Twitter, which is not a network designed solely for professional use, allows subscribers to give their opinion, to follow some influencers but also to exchange personal information. LinkedIn is a broader professional network that covers all professions (not just researchers) and provides access to the global careers of subscribers without highlighting academic work. ResearchGate is reserved for researchers, and is used to promote their works and to connect with people working in the same field of research. We did not analyse other famous social networks (e.g. Instagram, Facebook, Google+) but, as these networks are mainly dedicated to recreational use and are rarely used by physicians in a professional context, it did not seem relevant to us to include them in a study dedicated to the visibility of female researchers. In our work, the rates of Twitter use among anaesthesia researchers (between 22% and 25%) are close to those recently described (between 28% and 30%) among health policy and health services researchers.[6] However, unlike the work of Zhu and colleagues,[6] we found no differences in the number of followers between men and women. LinkedIn data also showed similar visibility for both sexes although, among prolific authors, the rate of researchers with more than 500 contacts was higher among men. On ResearchGate, men and women had similar subscription rates, similar presence of a photograph, and similar number of reported skills. Nevertheless, women's visibility on this network was much lower with visibility/reputation scores and number of followers significantly higher for men. These findings were similar in all three sub-populations of researchers studied, and these trends appeared to be more pronounced among FA. Our exploratory work did not allow us to analyse the causes of women's low visibility on ResearchGate. It is likely that the Internet research community is only a mirror image of the 'real' academic community, with a superior visibility of men. It would have been relevant to propose to the included researchers to participate to an online complementary survey to analyse the factors that determine their use of social networks (frequency of messages, decision to follow another researcher, etc.). As it is relatively easy to find researchers' e-mail addresses, the use of this type of questionnaire may be the subject of a future work. It would also be interesting to study the algorithms of ResearchGate to explore whether this website suggests consulting the profiles of men more often than women's. The concept of 'skills' on ResearchGate are skills that the researcher can attribute to himself (and that their followers must validate) or that followers can suggest for a given researcher. Thus, it is a rather subjective data, easily modifiable, and it appeared difficult to get a clear message from the difference observed between men and women in the FA group.

Our study has several limitations. First, this work was limited to four anaesthesia journals, mainly US journals. As previously stated, in 2016 and 2017, the *British Journal of Anaesthesia* and *Anaesthesia* only gave last names and the initials of the first names of their authors.[2] It was therefore difficult to find the sex of the authors in a reliable and reproducible way for these two journals. As they are two major journals in our specialty, this most likely leads to a bias in our results (with probably an over-representation of American authors and an under-representation of European authors). Since the beginning of 2019, the *British Journal of Anaesthesia* has provided the full first names of its authors, which will make it easier to assess the rate of women publishing in this journal. Second, this work focuses on a limited population of anaesthesia researchers. Social networks evolve very quickly (subscription/unsubscription, new followers/loss of followers, etc.), so it is essential to use data collected over a short period (here, 10 days). However, in view of the manual standardised procedure needed to detect all the accounts (which is time-consuming), the number of researchers which could be included was limited. The choice of the denominator of our

Table 1 Comparison of professional social media use among the first authors regarding their gender. Data are presented as absolute values and percentages (*n* (%)) or median [inter-quartile range]. The 'number of citations' section refers to the number of times the first author's article was cited in 2016 and 2017 in the journals analysed.

	Total	Men	Women	P
N (%)	260 (100%)	166 (63.8%)	94 (36.2%)	
Number of citations	9 [7–13]	9 [7–12]	9 [7–13]	0.90
At least one professional social media account	215 (82.7%)	142 (85.5%)	73 (77.7%)	0.11
Twitter account	59 (22.7%)	42 (25.3%)	17 (18.0%)	0.22
Tweets	166 [53–941]	332 [87–1038]	70 [33–245]	0.01
Followers	168 [55–599]	151 [63–656]	188 [37–333]	0.34
Following	172 [29–475]	244 [29–525]	88 [24–207]	0.1
ResearchGate account	170 (65.4%)	116 (70.0%)	54 (57.4%)	0.04
Presence of a photograph	117 (68.8%)	86 (74.1%)	31 (57.4%)	0.03
Followers	43 [16–117]	55 [30–151]	21 [8–49]	<0.0001
Following	27 [8–50]	35 [12–72]	18 [6–35]	<0.001
Number of skills	8 [4–18]	9 [5–21]	7 [3–11]	0.01
RG score	28.4 [19.7–37.2]	32.0 [24.4–41.1]	20.3 [15.1–29.2]	<0.0001
Total Research Interest Score	289 [91–1012]	410 [138–1381]	177 [56–402]	<0.01
LinkedIn account	154 (59.2%)	105 (63.3%)	49 (52.1%)	0.08
Presence of a photograph	71 (46%)	49 (46.7%)	22 (44.9%)	0.84
>500 contacts	27 (17.5%)	21 (20.0%)	6 (12.2%)	0.27
If ≤500 contacts, number of contacts	95 [23–252]	119 [28–304]	67 [18–183]	0.05

work was arbitrary and the rate of women was assessed on the basis of a specific population of authors who already have a high visibility and publish in prestigious journals. These results are thus not necessarily generalisable to all anaesthesia researchers/journals. As it is very difficult to know at which stage of career each researcher is, it is possible that the most visible researchers are those at the end of their careers, but it was not possible to find this information reliably for all the researchers studied. Moreover, we based our selection of articles/authors on the JCR and the Web of Science Database, which do not indicate if the second author is in fact a 'second first author' with joint first authorship. It is therefore possible that we have missed researchers positing as the co-first author of a work but only appearing in second place in the list of authors. Third, our data only analyse a short and recent period, but the use of professional social media has increased in recent years and the feminisation of publications in anaesthesia is increasing.[2] It would therefore not have been relevant to look for data older than 5–6 years in this context. Fourth, the exclusion of authors where sex was unable to be determined represents another source of bias. Moreover, because of cultural differences, it may sometimes be difficult for an English-speaking researcher to accurately establish the sex of an Asian author with only the name (especially in very large research institutions with several homonyms). This limitation was already pointed out by Ioannidis and colleagues,[12] who identified a large part of these authors in their bibliometric analysis. A generalisation of ORCID numbers could be a good method to assess the sex of an author by removing problems related to homonymy. Fifth, even a

Table 2 Comparison of professional social media use among the last authors regarding their gender. Data are presented as absolute values and percentages (*n* (%)) or median [inter-quartile range]. The 'number of citations' section refers to the number of times the last author's article was cited in 2016 and 2017 in the journals analysed.

	Total	Men	Women	P
N (%)	232 (100%)	193 (83.2%)	39 (16.8%)	
Number of citations	9 [7–14]	9 [7–14]	9 [7–13]	0.47
At least one professional social media account	186 (80.2%)	153 (79.3%)	33 (84.6%)	0.45
Twitter account	58 (25.0%)	48 (24.9%)	11 (28.2%)	0.69
Tweets	109 [15–341]	94 [8–391]	117 [46–298]	0.74
Followers	169 [39–741]	215 [37–859]	109 [56–427]	0.71
Following	67 [33–305]	67 [31–320]	80 [49–128]	0.94
ResearchGate account	144 (62%)	115 (59.6%)	29 (74.4%)	0.08
Presence of a photograph	100 (69.4%)	83 (72.2%)	17 (58.6)	0.16
Followers	88 [55–201]	96 [55–230]	74 [54–113]	0.04
Following	35 [16–67]	35 [16–73]	27 [11–57]	0.66
Number of skills	9 [4–16]	10 [4–16]	7 [3–18]	0.64
RG score	38.3 [33.5–43.0]	39.3 [34.3–43.4]	35.7 [30.3–39.5]	0.01
Total Research Interest Score	1299 [524–2685]	1367 [665–2914]	731 [272–1721]	0.06
LinkedIn account	131 (56.5%)	107 (55.4%)	24 (61.5%)	0.7
Presence of a photograph	53 (40.5%)	40 (37.4%)	13 (54.2%)	0.17
>500 contacts	33 (25.2%)	28 (26.2%)	5 (20.8%)	0.80
If ≤500 contacts, number of contact	122 [11–336]	122 [8–347]	95 [46–333]	0.55

Table 3 Comparison of professional social media use among the most prolific authors regarding their gender. Data are presented as absolute values and percentages (*n* (%)) or median [inter-quartile range]. The 'number of citations' section corresponds to the number of articles published in the four journals studied, in which the author participated during the period 2013–2018.

	Total	Men	Women	*P*
N (%)	297 (100%)	249 (83.8%)	48 (16.2%)	
Number of citations	9 [7–12]	9 [7–12]	9 [7–11]	0.38
Continent:				
- North America	196 (66.0%)	160 (64.3%)	35 (72.9%)	0.32
- Other	101 (34.0%)	89 (35.7%)	13 (27.1%)	
At least one professional social media account	250 (84.2%)	206 (82.7%)	44 (91.7%)	0.12
Twitter account	70 (23.6%)	60 (24.1%)	10 (20.8%)	0.71
Tweets	149 [27–461]	127 [26–437]	215 [49–995]	0.70
Followers	208 [66–638]	208 [80–583]	335 [58–871]	0.77
Following	102 [48–295]	98 [47–310]	107 [63–277]	0.65
ResearchGate account	213 (71.7%)	180 (72.3%)	33 (68.8%)	0.50
Presence of a photograph	146 (68.5%)	125 (69.4%)	21 (63.6%)	0.51
Followers	102 [51–206]	124 [56–235]	77 [37–151]	0.02
Following	30 [12–61]	34 [14–68]	24 [9–42]	0.12
Number of skills	9 [3–19]	10 [3–19]	7 [2–22]	0.27
RG score	40.6 [34.9–45.3]	41.5 [35.6–45.7]	36.8 [28.1–42.7]	<0.01
Total Research Interest Score	1446 [496–3114]	1524 [612–3539]	874 [138–2055]	0.02
LinkedIn account	185 (62.3%)	149 (59.8%)	36 (75.0%)	0.05
Presence of a photograph	132 (71.4%)	109 (73.2%)	23 (63.9%)	0.27
>500 contacts	57 (30.8%)	49 (32.9%)	8 (22.2%)	0.02
If ≤500 contacts, number of contact	153 [30–285]	148 [48–312]	159 [11–255]	0.38

standardised manual account search procedure has its flaws; some authors may use a pseudonym, a diminutive (e.g. Matt instead of Matthew) or misspell their name when they register, etc. Sixth, the bibliometric parameters of ResearchGate are specific to this website and quite subjective in their calculations. Their calculation method (linear or exponential) is unknown, and if scores are calculated exponentially, it is possible that the difference between men and women could be less significant than that described in our study. Moreover, these scores only take into account the interactions between researchers registered on the website. Nevertheless, they have the merit of quantifying the work visibility of a researcher and comparing it with that of other registered researchers. In addition, it has been shown that ResearchGate scores are correlated with the academic level of registered researchers.[11] Finally, our work analysed the 'social' or biological sex of the authors but did not take their gender into account. Our technique therefore did not allow us to detect whether a person is transgender or intersex. Unfortunately, at the present time, there is no way to circumvent this limitation in a bibliometric work.

Conclusion

Social networks are sometimes presented as an alternative to male conservatism in academia.[13] However, in anaesthesia research, we found that on the only social network dedicated to scientific research, the visibility of women remains lower than that of men despite similar scientific skills reported. A study to determine the factors that lead researchers to follow or cite some of their colleagues on the Internet could reveal the mechanisms involved in this difference of visibility between men and women.

Authors' contributions

Study conception and design: ZD, EB, TC
Acquisition of data: ZD, GB, TC
Statistical analysis: ZD, TC
Data analysis and interpretation: ZD, GB, JS, VC, EB, TC
Drafting of the manuscript: ZD, GB, TC
Manuscript revision: JS, VC, EB
All authors have read and approved the final manuscript

Declaration of interests

The authors declare that they have no conflicts of interest.

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