Bibliometric Analysis of Authorship Trends and Collaboration Dynamics over the Past Three Decades of *BONE's* Publication History

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Abstract

The existence of a gender gap in academia has been a hotly debated topic over the past several decades. It has been argued that due to the gender gap, it is more difficult for women to obtain higher positions. Manuscripts serve as an important measurement of one's accomplishments within a particular field of academia. Here, we analyzed, over the past 3 decades, authorship and other trends in manuscripts published in *BONE*, one of the premier journals in the field of bone and mineral metabolism. For this study, one complete year of manuscripts was evaluated (e.g. 1985, 1995, 2005, 2015) for each decade. A bibliometric analysis was then performed of authorship trends for those manuscripts. Analyzed fields included: average number of authors per manuscript, numerical position of the corresponding author, number of institutions collaborating on each manuscript, number of countries involved with each manuscript, number of references, and number of citations per manuscript. Each of these fields increased significantly over the 30-year time frame ($p<10^{-6}$). The gender of both the first and corresponding authors was identified and analyzed over time and by region. There was a significant increase in the percentage of female first authors from 23.4% in 1985 to 47.8% in 2015 ($p=0.001$). The percentage of female corresponding authors also increased from 21.2% in 1985 to 35.4% in 2015 although it was not significant ($p =0.07$). With such a substantial emphasis being placed on publishing in academic medicine, it is crucial to comprehend the changes in publishing characteristics over time and geographical region. These findings highlight authorship trends in *BONE* over time as well as by region. Importantly, these findings also highlight where challenges still exist.

Keywords: Gender, bibliometric analysis, authorship trends, bone

1. Introduction

According to the dictionary definition, the “gender gap” simply refers to the differences between men and women in areas such as economics, politics, etc [1]. However, in more recent years, it has come to denote disparities in compensation (including financial and corporate/academic position) between men and women with equal skills and training [2]. The biggest question has become “why?” Why does this gap exist, and what factors created this gap? As of 2017, women make up 49.6% of the world population [3]. Since the end of World War II, the percentage of female students in universities increased from 32% to 56% [4]. With such statistics, it would seem intuitive that women should also hold ~50% of professional-level jobs. However, women only hold 14.6% of CEO positions and only comprise 8.1% of top earners financially [5]. These discrepancies are similar in medicine. Women comprise 47% of medical students and 46% of residents; however, they account for 21% of full-time professors, 15% of department chairs, and 16% of deans [6-8]. As publications are an important indicator of a person’s scholarly output and reputation, one of the factors responsible for this discrepancy in professional equality may be the number of publications.

The primary purpose of a publication is to advance knowledge in a given field. In academia, publications are also a crucial factor for personal advancement in both the field and the promotion tenure track [9-14]. Additionally, publications are gaining importance in the application process for professional schools, graduate schools, and residency programs [15]. Reviewing the authorship trends of academic journals, as well as the correlation to the increase in females pursuing academic roles, provides valuable information regarding the degree to which the gender gap does or does not prevail and likely future trends for women in academic medicine.

The journal *BONE* focuses on “basic, translational and, clinical aspects of bone and mineral metabolism” [16]. It was hypothesized the while the percentage of female authors would increase overtime, the percentage of females authors would still be lower than the percentage of male authors, even in 2015. Therefore, the purpose of this study to undertake a historical analysis of *BONE* with a specific focus on authorship gender.

2. Materials and Methods

2.1. Data Collection Process: Manuscripts

Authorship trends in *BONE* were performed over a 30 year period. The data was analyzed in ten-year intervals dating from 1985 to 2015. This periodic sampling technique has been previously described and validated [17-21]. We selected 1985 as the starting year, and 2015 as the final year, as it was the most recent year with a complete set of publications since our study commenced in 2016. The gender of both the first author and the corresponding author were documented, which allowed us to analyze gender of both authors. We also studied other demographics including geographic location and other bibliometric variables.

All articles in the journal for each of the sample years were included except for editorials, letters, and commentaries. EndNote X7 (Clarivate Analytics, Philadelphia, PA) was used to examine and organize the publications from these journals. Publications that did not contain an author were excluded as well as memorandums, meeting notes, and abstracts and all publications that were available electronically prior to editorial typesetting etc. (e.g. e-pub ahead of print) for that specific year but not published until the following year. The organized EndNote data was then exported into a Microsoft Excel (Microsoft, Redmond, WA) file.

The countries in which the corresponding author resided was noted; the state or province for those in the United States or Canada was also tabulated. The chronological author position of the corresponding author (e.g. 1,2,3…last author) was captured. The number of references cited, and publication length (total printed page number). The number of times each publication had been cited was also recorded, and was obtained via a Scopus search of each specific publication. All Scopus searches were completed in November of 2016.

Gender was identified for both the first and corresponding authors using a "Baby Name Guesser" website (http://www.gpeters.com/names/baby-names.php) [17]. This approach has been used and validated by others [17-21]. In brief, the first name was entered and the website provided a most likely gender as well as a gender ratio. A ratio of 3.0 or higher was considered to be a correct identification of gender. If a ratio of less than 3.0 was obtained, then the author's gender was confirmed via a Google search. If the search did not result in confirming the author's gender, then the entry was excluded. For corresponding authors, 2.8% of all entries were excluded and for first authors 2.7% were excluded.

2.2. Assignment of Geographical Region: Manuscripts

Countries were organized into groups by region for the corresponding author. Countries were assigned to the authors based on the location of corresponding author's institution(s). Canada and the United States of America were considered to be North America. Mexico, Central and South America were grouped as Latin America. All European countries, as well as Turkey and Russia were grouped into the Europe category. Asia was all Asian countries starting west of Turkey as well as the Middle East and Israel. The other regions were described as Africa and Australia/New Zealand which we define as Oceania for the purposes of this study.

2.3 Editorial Board Data Collection

The composition of the editorial board was identified during the years studied (1985, 1995, 2005, and 2015). Specifically, the names and countries of residence for editor(s), managing editor(s), associate editor(s), and editorial board members was collected. The names were analyzed as detailed above for gender and the countries were grouped into regions as described above.

2.4 Statistical Analysis

Continuous data are reported as the mean ±1 standard deviation. Discrete data are reported as frequencies and percentages. Analyses between groups of continuous data were performed using non-parametric tests due to the data not having normal distributions (Mann-Whitney U – 2 groups; Kruskal-Wallis test – 3 or more groups). Differences between groups of discrete data were analyzed by the Fisher's exact test (2 x 2 tables) and the Pearson's χ^2 test (greater than 2 x 2 tables). Trends over time (2 x k tables) were analyzed with the Cochran linear trend test. For all statistical analyses a $p < 0.05$ was considered statistically significant. Statistical analyses were performed with Systat 10 software™ (Systat Software, Chicago, IL).

3. Results

A total of 899 publications met the inclusion requirements; there were 67 from 1985, 258 from 1995, 219 from 2005, and 355 from 2015.

3.1. Analyses by Region

Due to the small number of manuscripts from Africa and Latin America, these regions were excluded from further analyses (2.2% of total manuscripts). The percentage of publications originating from the included regions was: 39.5% for North America, 36.9% for Europe, 16.4% for Asia, and 5.0% for Oceania.

The distribution of publications by individual countries and states/provinces was analyzed (Figure 1). For North America, 87.9% came from the United States and 12.1% from Canada. Within the United States, California, Massachusetts, and New York had the most manuscripts and accounted for 28.5% of the United States' manuscripts (Figure 1A). For Europe, 37.6% originated in France and the United Kingdom (Figure 1B). For Oceania, 95.5% originated from Australia (Figure 1C). For Asia, 71.4% originated from Japan and China (Figure 1D).

3.2. Trends over Time and Region

The number of publications increased from 67 in 1985 to 355 in 2015 (Figure 2A). The average number of authors increased from 3.6±1.6 in 1985 to 7.1±3.6 in 2015 (Figure 2B). The corresponding author position (e.g. 1^{st}, 2^{nd}, 3^{rd}, etc…, last) increased from 1.4±0.9 in 1985 to 4.3±3.8 in 2015 (Figure 2B). The number of institutions collaborating per manuscript increased from 1.5±0.7 in 1985 to 2.9±2.0 in 2015 and the number of countries collaborating per manuscript increased from 1.2±0.4 in 1985 to 1.5±0.9 in 2015 (Figure 2C). The average number of printed pages per manuscript increased from 5.8±2.4 in 1985 to 8.4±2.3 in 2015 (Figure 2D). The average number of references per manuscript increased from 24±14 in 1985 to 52±1 in 2015 (Figure 2E). Due to the fact that the 2015 manuscripts had only been published for a single year at the time the data was collected, the citation data we quote was normalized by dividing the amount of times the composition was cited by the age of the manuscript (31 for 1986, 21 for 1995, 11 for 2005, and 1 for 2015). Using this normalized citation method, the number of times each paper was cited increased significantly from 0.9±1.1 in 1985 to 3.6±4.3 in 2015 (Figure 2F). All of these changes over time were significant ($p<10^{-6}$).

The publications were also analyzed using the same parameters based on the region of origin. There were 356 manuscripts from North America, 332 from Europe, 147 from Asia, and 45 from Oceania (Figure 3A). The average number of authors per paper varied significantly between regions with Asia having the highest average of 6.4±2.6, followed by Europe at 5.9±3.0, North America at 5.4±3.2, and Oceania at 5.1± 2.2 (Figure 3B, p = 0.0002). The average corresponding author position was lowest for Europe at 2.9±3.1 followed by North America at 3.3±1.4, Oceania at 3.3±2.6, and Asia at 4.0±3.2 (Figure 3B, p = 0.0002). The number of collaborating institutions also varied significantly between regions; North America had 2.2±1.4, Europe 2.6±2.1, Asia 2.4±1.4, and Oceania 2.4±1.2 (Figure 3C, p = 0.04). Manuscripts from Europe had the highest number of collaborating countries at 1.5±1.1, followed by Asia at 1.3±0.7, North America at 1.2±0.5, and Oceania at 1.2±0.4 (Figure 3C, p = 0.0003). The average number of printed pages per paper differed slightly by region with North America at 7.8±2.5, Europe at 7.6±2.6, Asia at 7.2±2.4, and Oceania at 7.7±2.2 (Figure 3D, p = 0.004). The average number of references cited for each manuscript was not different between regions: Asia (38±16), North America (43±26), Europe (41±30), and Oceania (46±33) (Figure 3E, $p = 0.2$). Geographic region also did not significantly affect the number of normalized citations (Figure 3F, $p = 0.9$).

3.3. Gender Distribution of Authors over Time by Region

The percentage of female corresponding authors significantly increased from 21.2% in 1985 to 35.4% in 2015 (χ^2 $p = 0.001$, Cochran linear trend $p = 0.0001$) (Figure 4A). As for the percentage of female corresponding authors by region, Oceania had the highest with 38.6%, followed by Europe (33.3%), and North America (28.5%). Asia had the lowest percentage with only 16.0% of female authors holding the corresponding author position (Figure 4B). The percentage of female first authors also increased from 23.4% in 1985 to 47.8% in 2015 (χ^2 $p < 10^{-6}$, Cochran linear trend $p < 10^{-6}$) (Figure 4C). The percentage of female first authors by region followed a trend similar to that of the female corresponding authors by region. Oceania had the highest percentage with 46.5%, followed by Europe with 42.1%, North American with 38.2%, and Asia with 22.5% (Figure 4D).

3.4 Gender Combinations between First and Corresponding Authors

Combinations between first and corresponding authors were analyzed. These combinations were defined as MM (both first and corresponding authors male), MF (first author male and corresponding author female), FM (first author female and corresponding author male), and FF (both first and corresponding authors female). There were significant changes over time for all combinations. There was a significant decrease in the MM combination from 76.6% in 1985 to 43.9% in 2015 ($p < 10^{-6}$, Cochran linear trend), while there was a significant increase over time for all other combinations. For FF, it increased from 20.3% in 1985 to 27.7% in 2015 ($p = 0.001$, Cochran linear trend); for FM it increased from 3.1% in 1985 to 21.0% in 2015 ($p < 10^{-6}$, Cochran linear trend), and for MF it increased from 0% in 1985 to 7.3% in 2015 ($p = 0.008$, Cochran linear trend) (Figure 5).

3.5 Editorial Board Composition

The composition of the editorial board (comprised, of editors, managing editors, associate editors, and editorial board members) was examined with respect to gender and region over time. No significant differences over time were detected with respect to region ($p = 0.4$). The percentage of editorial board members was: Africa (range: 0.0-0.9%), Oceania (range: 2.0-7.9%), Asia (range: 3.9-14.9%), Europe (range: 26.3-31.4%), and North America (range: 50.0-62.7%). As the number of editorial board members was small for both Africa and Oceania, these regions were excluded from further analyses. Figure 6A shows the percentage of editorial board members from Asia, Europe, and North America over time. Figure 6B shows the percentage of manuscripts published in *BONE* over the same time period. We noted a trend for a higher percentage of editorial board members from North America compared to the percentage of manuscripts originating from North America, while the percentage of editorial board members from both Europe and Asia was lower than the percentage of manuscripts originating from these regions. However, this was not significant upon 3 way (year by region by role [editorial vs. author]) statistical testing (χ^2, $p = 0.73$).

With regard to gender, there was a statistically significant increase in female editorial board membership, from 5.9% in 1985 to 21.9% in 2015 (p=0.007, Cochran linear trend). This parallels what was observed for both first and corresponding authors as is shown in Figure 7.

4. Discussion

Publication is a crucial aspect of developing an academic career and is also used as a measurement of achievement and productivity within a specific field [9-14]. In order to establish whether or not modern gender parity has had any impact on female authorship in the bone and mineral metabolism field, we studied the gender of first and corresponding authors in *BONE* over the last 30 years (1 year per decade: 1985, 1995, 2005, and 2015). When discussing authorship, two of the most important positions are that of the first or corresponding author. Generally, the first author is the individual who contributed the most to the work, including composing the manuscript, and is usually a more junior colleague or mentee. The corresponding author is generally responsible for the study design and the research usually is conducted in his or her laboratory/division, although they may not have actually performed the research they were mentors and instrumental in guidance of the study [22-24].

We noted a significant 104% increase in the percentage of female first authors in *BONE* over the last 30 years. Similarly, for corresponding authorship, there was a significant 67% increase in the percentage of female corresponding authors. Corresponding authorship is important for the advancement of one's career in the field of academia, and demonstrates responsibility for the actual contents of a study [23]. Increases in female corresponding authorship indicate that the gender gap is closing, although there is still room for improvement with only 35% of corresponding authors being female.

The percentage of females in the first author position (47.8%) greatly exceeds that of the corresponding author position (35.4%). The most plausible explanation for this discrepancy is that women occupy fewer upper level positions in academic medicine [5]. As the percentages of both female first authors as well as female corresponding authors have increased over the past 30 years, we hypothesize that these percentages will continue to equalize in the future.

Of note, we also studied the gender composition of the editorial board over the same time period. As shown in Figure 7, there was a significant increase in the percentage of female editorial board members from 5.9% in 1985 to 21.9% in 2015. This increase paralleled the increases observed in both female first and corresponding authorship. These data may suggest that the number of senior females in the field has increased with time as presumably both editorial board positions and corresponding author positions would generally be held by more senior investigators. Of notice, the percentage of female board members is lower than the percentage of first or corresponding authors, yet all show an increase in the percentage of females with time. This may suggest that inclusion of even more female editorial board members would further increase the percentage of female first and corresponding authors, a possible solution to further closing gender-based gaps to more accurately represent the current makeup of females to males in the bone research field. Although a primary focus of this study was to identify trends between gender and authorship position, other trends were also analyzed. The position of the corresponding author shifted over time, with the average position going from 1.4 in 1985 to 4.3 in 2015 (207% increase). This increase correlates with the increasing number of authors (3.6 in 1985 to 7.1 in 2015, 97% increase) per manuscript. These findings are consistent with other studies, which have noted an increase in the number of authors over time [25]. Manuscript publication is a crucial part of an academic résumé, and collaborations have increased, allowing researchers to magnify their number of publications. This increase results in senior researchers, who generally hold the corresponding or middle author position, to be listed as authors while not necessarily being the first author [25].

With the emphasis placed on not just the quality but also the quantity of publications, there has been an increase in authorship number. With this increase in authorship number, there may also be a lack of accountability regarding the contents of the study [26]. While responsibility for the published information generally falls on the corresponding author, the emerging belief is that all authors on the paper are responsible [27]. The increasing in the number of authors per manuscript, while it may result in a decrease in overall accountability for published information, may simply be a reflection of the overall complexity of research and increase in collaboration, although not all agree [28-32].

With technology advancements, collaborations on studies between institutions have more than doubled [33]. Collaborations are essential to increasing the efficiency, efficacy, and scope of the scientific process and experimentation [30-32]. European manuscripts had the highest number of institutions, as well countries per manuscript, and number of citations per paper [34]. Notably, Europe generates 33% of the world's research, compared to the United States at 23% [35]. This may reflect the ability of Europeans to work throughout the European Union and/or could be due the need of smaller countries to collaborate more than those larger (eg. United States) or, more geographically isolated countries [36, 37].

In this study, the majority of manuscripts originated from North America, then Europe, then Asia. Interestingly, as illustrated in Figure 6, the region of residence of editorial board members paralleled the origin of the manuscripts, with one exception. The percentage of manuscripts published from North American authors was lower than the percentage of editorial board members from North America, whereas the percentage of manuscripts published from both Europe and Asia was higher than the percentage of editorial board members from Europe and Asia. However, this was not significant upon 3 way (year by region by role [editorial vs. author]) statistical testing (χ^2, p=0.73). With respect to regional manuscript breakdowns, California contributed the largest number of manuscripts from North America, the United Kingdom the largest number from Europe, Australia the largest number from Oceania, and Japan the largest number from Asia. These trends are understandable by studying the research institutions in each region. For example, California has the most universities in the United States, while the East coast is home to some of the most prestigious institutions in the world [35] and the highest manuscript contributions in the United States were seen from California, New York, and Massachusetts.

BONE has "an unsurpassed reputation for excellence" [38]; with an impact factor of 4.140 and a 5 year impact factor of 4.388, *BONE* is in the top 10% of all research journals. Impact factor measures the average number of citations per article in a journal, and *BONE's* citation/article have increased 300% from 1985 to 2015, cementing *BONE's* impact factor.

In conclusion, over the last 30 years, manuscripts in *BONE* have shown a significant increase in the number of authors, collaborating institutions and countries, references cited, printed pages, citations received, female first authors, and female corresponding authors. The gender gap has decreased, particularly for female first authors. However, work remains to continue shrinking the gap for female corresponding authors and females in general in the medical field. Although not explicitly proven here, one step toward shrinking the authorship gender gap may include increasing the percentage of female editorial board members as female authorship paralleled female editorial board composition.

Conflicts of Interest

The authors declare no conflicts of interest.

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References:

[1] Dictionary.com; Gender Gap; http://www.dictionary.com/browse/gender-gap. Accessed August 26, 2017.

[2] National Center for Education Statistics; Total fall enrollment in degree-granting postsecondary institutions, by level of enrollment, sex, attendance status, and age of student: 2011, 2013, and 2015; https://nces.ed.gov/programs/digest/d16/tables/dt16_303.45.asp. Accessed August 26, 2017.

[3] O. Indicators, Education at a glance 2016, Editions OECD (2016).

[4] C. Goldin, Gender gap, The Concise Encyclopaedia of Economics (1993).

[5] D.M. Lautenberger, V.M. Dandar, C.L. Raezer, The state of women in academic medicine: the pipeline and pathways to leadership, 2013-2014, Association of American Medical Colleges2014.

[6] U.S.C. Bureau, International programs: international data base, USCB Washington.

[7] J. Warner, Women’s leadership. What’s true, what’s false and why it matters, Center for American Progress 7 (2014).

[8] S. Fitzpatrick, A Survey of Staffing Levels of Medical Clinical Academics in UK Medical Schools as at 31 July 2014, London: Medical Schools Council (2015).

[9] M. Angell, Publish or perish: a proposal, Ann Intern Med 104(2) (1986) 261-262.

[10] E. Halperin, Publish or perish-and bankrupt the medical library while we're at it, Acad Med 74(5) (1999) 470-2.

[11] U.S. Neill, Publish or perish, but at what cost?, J Clin Invest 118(7) (2008) 2368.

[12] R.A. Brumback, “3.. 2.. 1.. Impact [Factor]: Target [Academic Career] Destroyed!” Just Another Statistical Casualty, J Child Neurol 27(12) (2012) 1565-1576.

[13] T.C. Erren, D.M. Shaw, P. Morfeld, Analyzing the publish-or-perish paradigm with game theory: The prisoner’s dilemma and a possible escape, Sci Eng Ethics 22(5) (2016) 1431-1446.

[14] S.S. Hasan, K. Ahmadi, Publish or perish: a mandate with negative collateral consequences, Acad Med 92(2) (2017) 140.

[15] D.P. Wickramasinghe, C.S. Perera, S. Senarathna, D.N. Samarasekera, Patterns and trends of medical student research, BMC Med Educ 13(1) (2013) 175.

[16] P. Tornetta III, J. Siegel, P. McKay, M. Bhandari, Authorship and ethical considerations in the conduct of observational studies, JBJS 91(Supplement_3) (2009) 61-67.

[17] M. Mimouni, S. Zayit-Soudry, O. Segal, Y. Barak, A.Y. Nemet, S. Shulman, N. Geffen, Trends in Authorship of Articles in Major Ophthalmology Journals by Gender, 2002–2014, Ophthalmology 123(8) (2016) 1824-1828.

[18] J.D. Feramisco, J.J. Leitenberger, S.I. Redfern, A. Bian, X.-J. Xie, J.S. Resneck, A gender gap in the dermatology literature? Cross-sectional analysis of manuscript authorship trends in dermatology journals during 3 decades, J Am Acad Dermatol 60(1) (2009) 63-69.

[19] A. Gu, N. Almeida, J.S. Cohen, K.M. Peck, G.A. Merrell, Progression of Authorship of Scientific Articles in The Journal of Hand Surgery, 1985–2015, J Hand Surg Am 42(4) (2017) 291. e1-291. e6.

[20] A.E. Wininger, J.P. Fischer, E.F. Likine, A.S. Gudeman, A.R. Brinker, J. Ryu, K.A. Maupin, S. Lunsford, E.C. Whipple, R.T. Loder, M.A. Kacena, Bibliometric Analysis of Female Authorship Trends and Collaboration Dynamics over JBMR's 30-Year History, J Bone Miner Res (2017).

[21] J.D. Lehman, W.W. Schairer, A. Gu, J.L. Blevins, P.K. Sculco, Authorship Trends in 30 Years of the Journal of Arthroplasty, J Arthroplasty 32(5) (2017) 1684-1687.

[22] P.F. Svider, Q. Husain, K.M. Mauro, A.J. Folbe, S. Baredes, J.A. Eloy, Impact of mentoring medical students on scholarly productivity, Int Forum Allergy Rhinol, 2014, pp. 138-142.

[23] S. Bhattacharya, Authorship issue explained, Indian J Plast Surg 43(2) (2010) 233.

[24] D. Riesenberg, G.D. Lundberg, The order of authorship: who's on first?, JAMA 264(14) (1990) 1857-1857.

[25] T. Economist; Why Research Papers Have so Many Authors; The Economist Newspaper. https://www.economist.com/news/science-and-technology/21710792-scientific-publications-are-getting-more-and-more-names-attached-them-why; Accessed July 21, 2017.

[26] R.M. Slone, Coauthors' contributions to major papers published in the AJR: frequency of undeserved coauthorship, AJR Am J Roentgenol 167(3) (1996) 571-579.

[27] D. Rennie, V. Yank, L. Emanuel, When authorship fails: a proposal to make contributors accountable, JAMA 278(7) (1997) 579-585.

[28] G. Tilak, V. Prasad, A.B. Jena, Authorship inflation in medical publications, INQUIRY: The Journal of Health Care Organization, Provision, and Financing 52 (2015) 0046958015598311.

[29] S.I. Papatheodorou, T.A. Trikalinos, J.P. Ioannidis, Inflated numbers of authors over time have not been just due to increasing research complexity, J Clin Epidemiol 61(6) (2008) 546-551.

[30] S. Wuchty, B.F. Jones, B. Uzzi, The increasing dominance of teams in production of knowledge, Science 316(5827) (2007) 1036-1039.

[31] H.J. Falk- Krzesinski, K. Börner, N. Contractor, S.M. Fiore, K.L. Hall, J. Keyton, B. Spring, D. Stokols, W. Trochim, B. Uzzi, Advancing the science of team science, Clin Transl Sci 3(5) (2010) 263-266.

[32] G. González-Alcaide, J. Park, C. Huamaní, I. Belinchón, J.M. Ramos, Evolution of Cooperation Patterns in Psoriasis Research: Co-Authorship Network Analysis of Papers in Medline (1942–2013), PLoS One 10(12) (2015) e0144837.

[33] J. Grabmeier, International Science Collaboration Growing at Astonishing Rate, Physorg (2017). https://news.osu.edu/news/2017/02/17/global-science/; Accessed August 28, 2017.

[34] J. Kamalski, A. Plume, Comparative Benchmarking of European and US Research Collaboration and Researchers Mobility: A Report Prepared in Collaboration Between Science Europe and Elsevier's SciVal Analytics, Elsevier 2013. http://www.scienceeurope.org/wp-content/uploads/2014/05/SE_and_Elsevier_Report_Final.pdf; Accessed August 28, 2017.

[35] J. Gurney-Read; Study in the US: East versus West; The Telegraph. http://www.telegraph.co.uk/education/universityeducation/11509649/Study-in-the-US-East-versus-West.html; Accessed July 21, 2017.

[36] D. Gal, W. Glänzel, K.R. Sipido, Mapping cross-border collaboration and communication in cardiovascular research from 1992 to 2012, Eur Heart J 38(16) (2016) 1249-1258.

[37] W. Glänzel, A. Schubert, Domesticity and internationality in co-authorship, references and citations, Scientometrics 65(3) (2005) 323-342.

[38] Thomson Reuters, Journal Impact Factor 2016: 2.44, 2016. https://jcr.incites.thomsonreuters.com/; Accessed August 30, 2017.

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Figure Legends:

Figure 1. Maps showing the countries and states/provinces from which publications are originating. Map of **A)** North America; **B)** Europe; **C)** Oceania; and **D)** Asia showing the countries or states/provinces contributing published manuscripts. Black represents the highest percentage of manuscripts published in the country or state/province. White indicates no manuscripts were published in the country or state/province.

Figure 2. Bibliometric trends over time. **A)** Number of published manuscripts meeting inclusion criteria. **B)** Number of co-authors and corresponding author position. **C)** Number of countries from which authors on manuscripts reside and the number of institutions collaborating on published manuscripts. **D)** Length of published manuscripts. **E)** Number of references cited within each manuscript. **F)** Number of times each published manuscript was cited in other manuscripts. Data in **B-F** are presented as the mean ± 1 standard deviation of the mean.

Figure 3. Trends by region. **A)** Number of published manuscripts meeting inclusion criteria. **B)** Number of co-authors and corresponding author position. **C)** Number of countries from which authors on manuscripts reside and the number of institutions collaborating on published manuscripts. **D)** Length of published manuscripts. **E)** Number of references cited within each manuscript. **F)** Number of times each published manuscript was cited in other manuscripts. Data in **B-F** are presented as the mean ± 1 standard deviation of the mean. North America = NA, EU = Europe, OC = Oceania.

Figure 4. Percentage of female corresponding and first authors by time and region. **A)** Gender distribution of corresponding authors over time. **B)** Gender distribution of corresponding authors by region. **C)** Gender distribution of first authors over time. **D)** Gender distribution of first authors by region.

Figure 5. Gender combinations between first and corresponding authors over time. MM = both first and corresponding authors are male, MF = first author is male and corresponding author is female, FM = first author is female and corresponding author is male, and FF = both first and corresponding authors are female.

Figure 6. Changes over time by region. **A)** Percentage of editorial board members from Asia, Europe, and North America. **B)** Percentage of *BONE* manuscripts originating from Asia, Europe and North America.

Figure 7. Percentage of female first authors, corresponding authors, and editorial board members over time. These changes were highly significant upon a 3 way χ^2 test (year by gender by role [1st author, corresponding author, editorial board]), $p<0.000001$.

Fig. 1

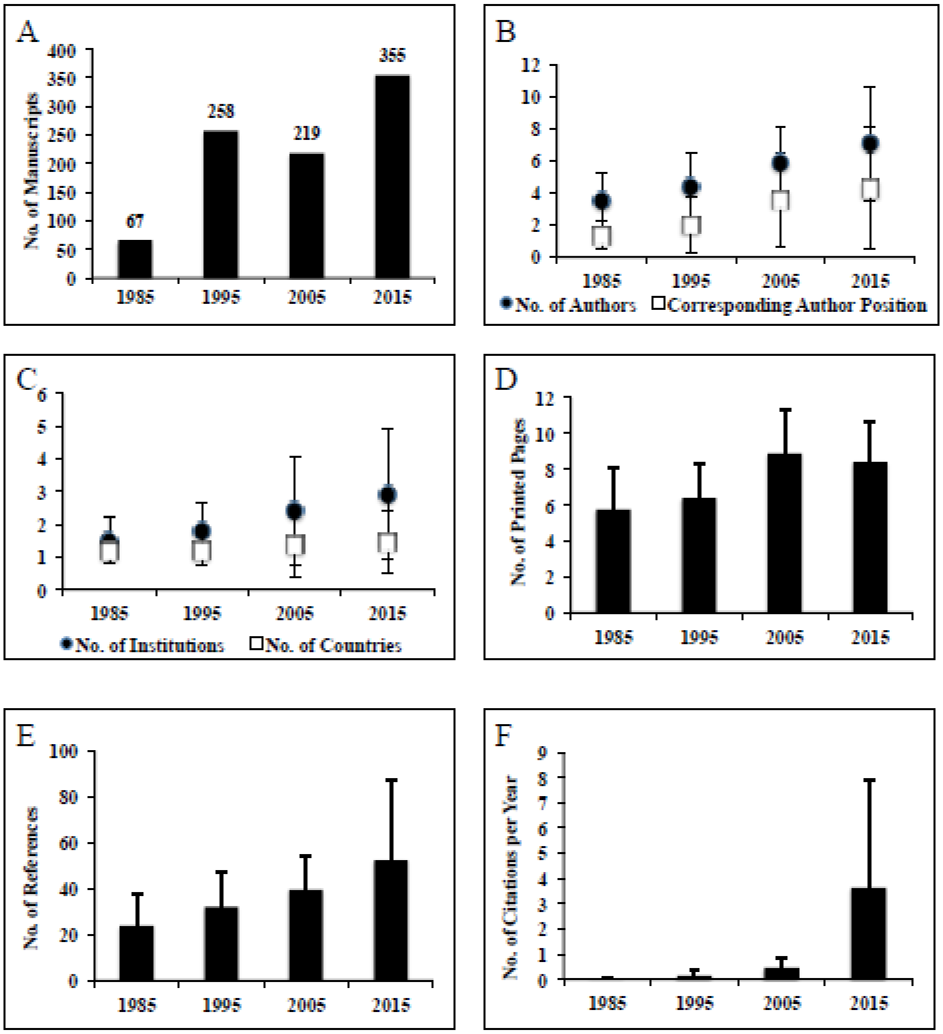
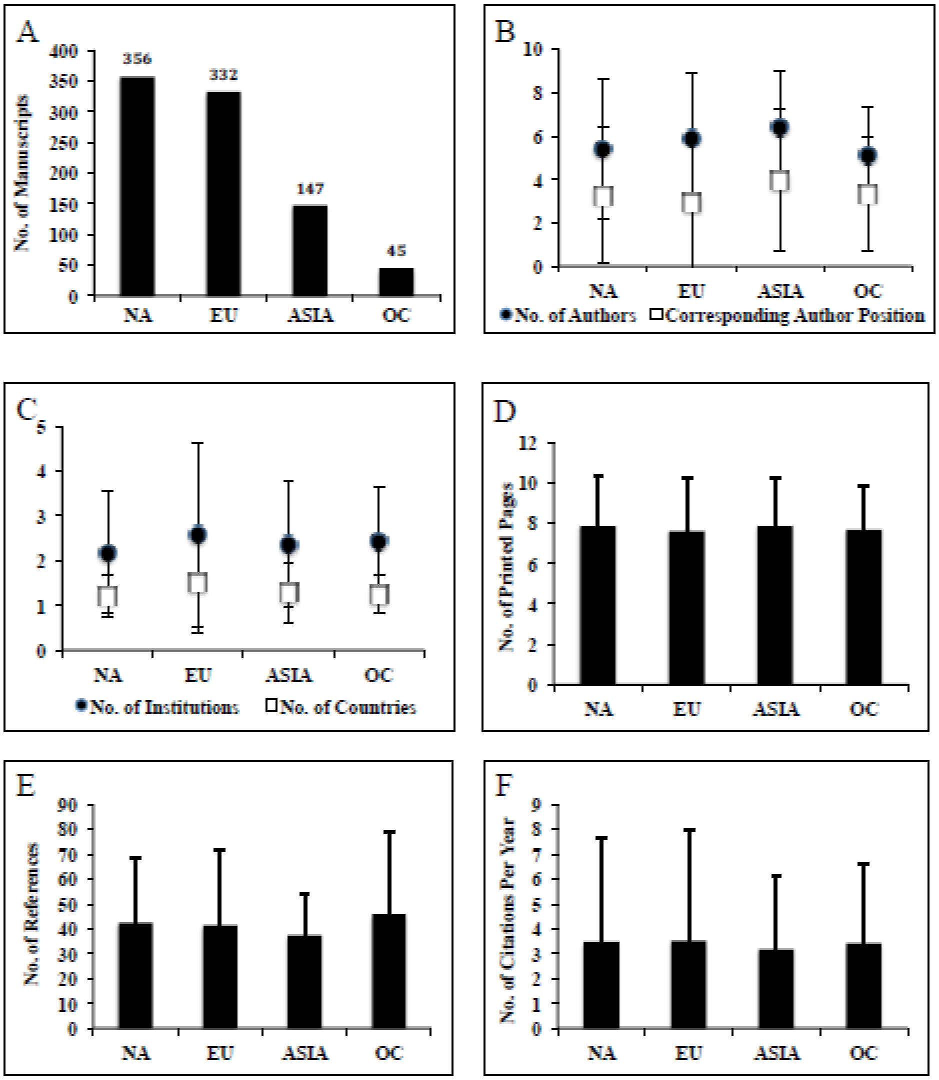

A
No. of Manuscripts
67
258
219
355
1985
1995
2005
2015
B
No. of Authors
Corresponding Author Position
C
No. of Institutions
No. of Countries
D
No. of Printed Pages
E
No. of References
F
No. of Citations per Year

Fig. 2


A
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350
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250
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No. of Manuscripts
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147
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NA
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ASIA
OC
B
10
8
6
4
2
0
NA
EU
ASIA
OC
No. of Authors
Corresponding Author Position
C
5
4
3
2
1
0
NA
EU
ASIA
OC
No. of Institutions
No. of Countries
D
12
10
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No. of Printed Pages
NA
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No. of References
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EU
ASIA
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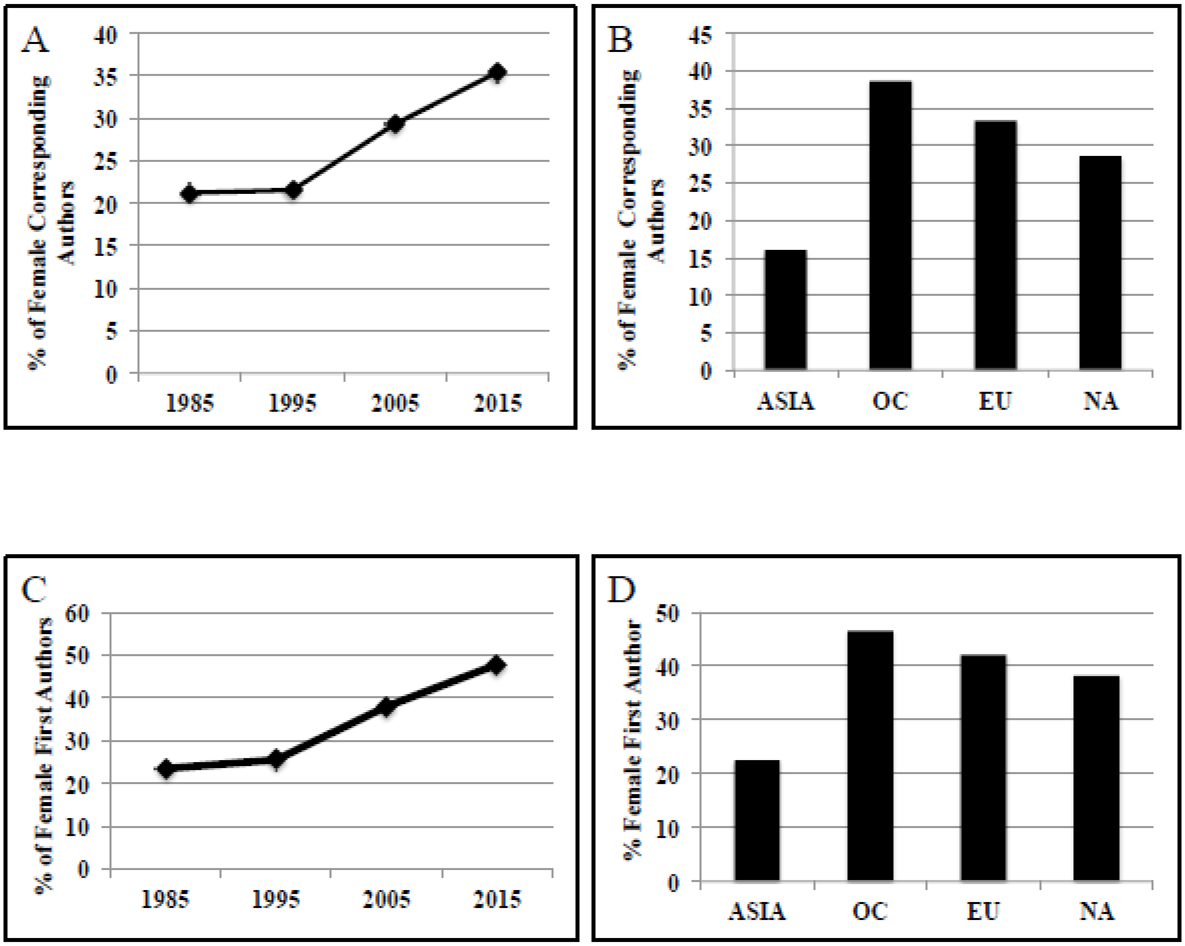
No. of Citations Per Year
NA
EU
ASIA
OC

Fig. 3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% of Female Corresponding Authors
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% of Female Corresponding Authors
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% of Female First Authors
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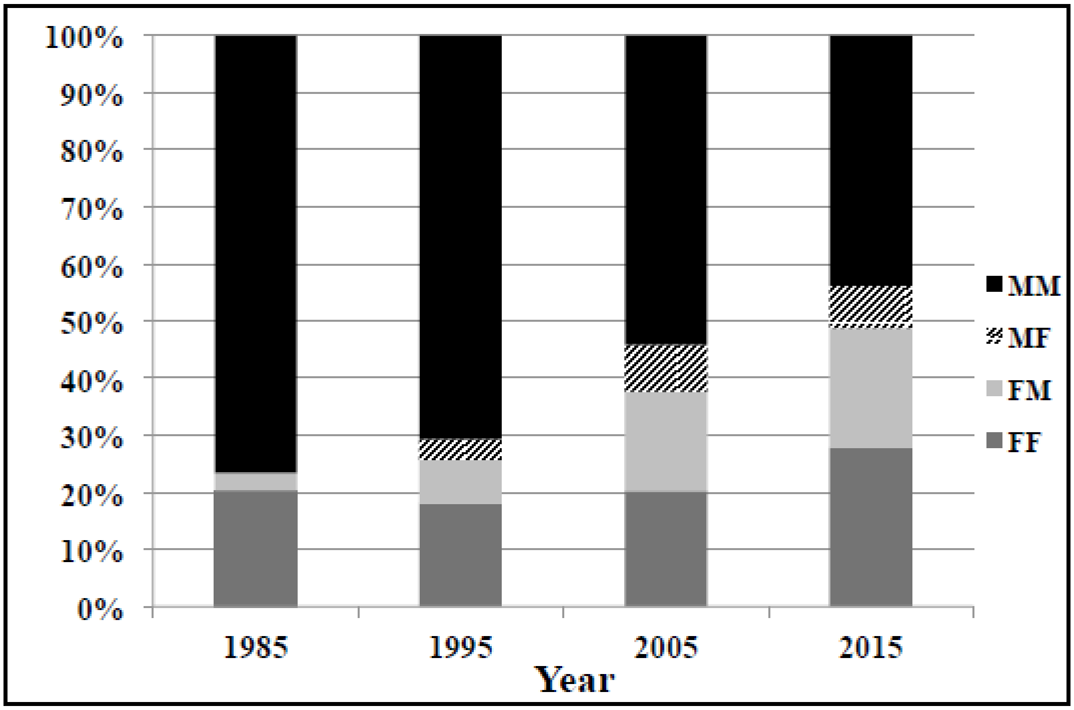
Fig. 4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Year
MM
MF
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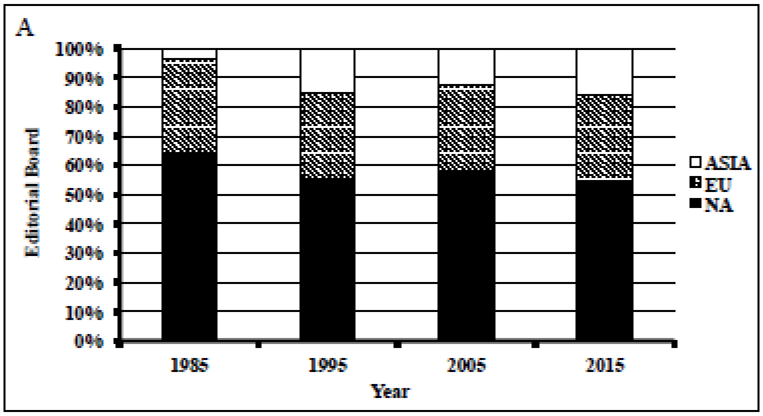
Fig. 5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Editorial Board
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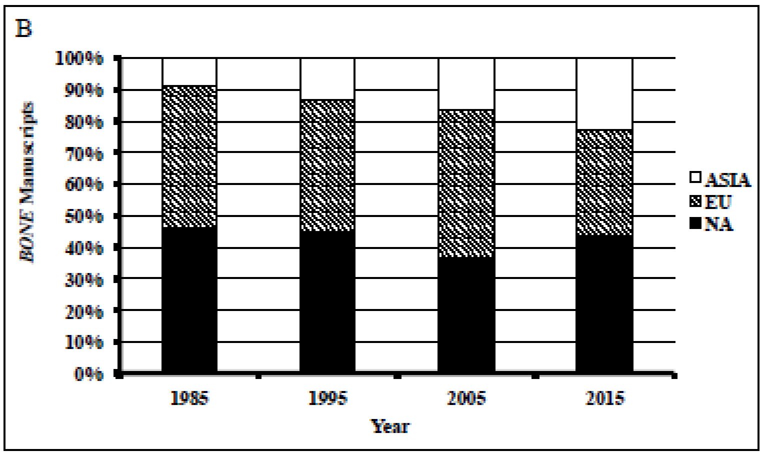
B
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BONE Manuscripts
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ASIA
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NA

Fig. 6

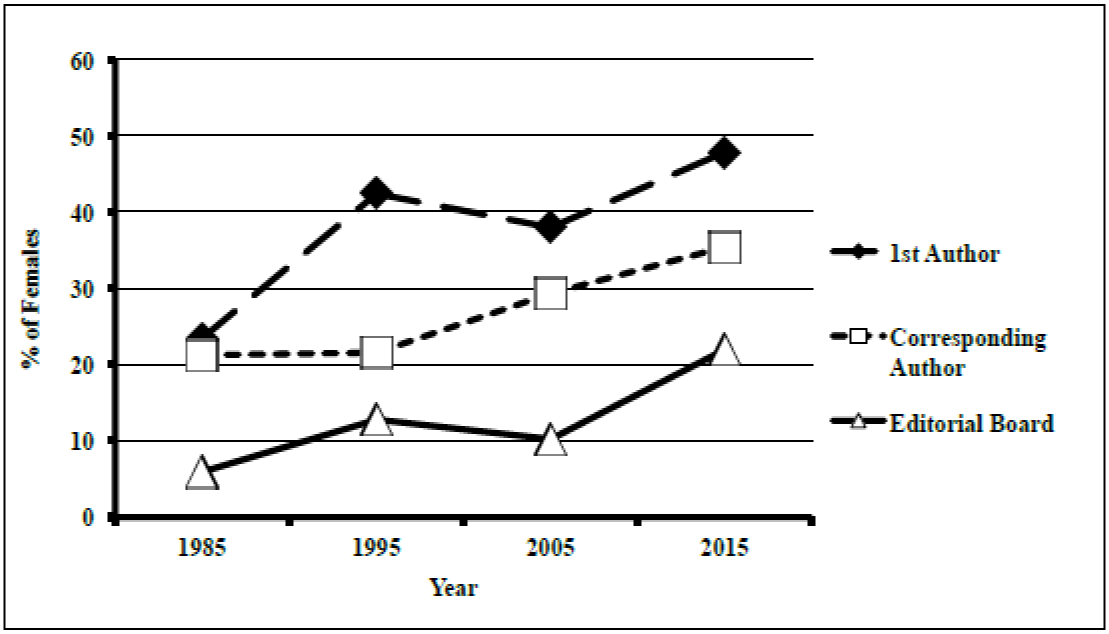
60
50
40
30
20
10
0
% of Females
1985
1995
2005
2015
Year
1st Author
Corresponding Author
Editorial Board

Fig. 7