Trend Toward an Increase in Authorship for Leading Radiology Journals

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OBJECTIVE. The purpose of this study was to determine authorship trends in two leading radiology journals over the past 2 decades.

MATERIALS AND METHODS. All original articles ($n = 5195$) published in *AJR* and *Radiology* for the periods 1991–1993, 2001–2003, and 2011–2013 were reviewed. The following variables were extrapolated from each article: number of authors, radiologic subspecialty, and country of origin. The number of authors listed per article was correlated with the publication period, journal, radiologic subspecialty, and country of origin.

RESULTS. The mean number of authors per article increased from 5.1 in 1991–1993 to 6.2 in 2001–2003 and to 7.1 in 2011–2013 across both journals ($p < 0.0001$). Both *AJR* and *Radiology* had statistically significant increases in the number of authors per article over time, but the number of authors per article in *Radiology* was significantly higher than that in *AJR* ($p < 0.0001$ for all study periods). The number of authors per article significantly increased for all radiologic subspecialties. The mean numbers of authors per article by country of origin are as follows: Italy, 8.3; Japan, 7.6; France, 7.5; Germany, 7.4; China, 7.3; Austria, 7.2; and South Korea, 6.8. These were significantly higher than the mean number of authors from Switzerland, which was 6.3.

CONCLUSION. The number of authors significantly and consistently increased in two leading radiology journals over the past 2 decades.

Publication of scientific articles, mainly original research, represents a means of communicating current scientific knowledge. Authorship of a scientific article indicates those who have made substantial contributions to the work and who should take public responsibility for the content [1, 2].

In the biomedical field, the concept of authorship has been a subject of great debate, mainly because of the trend toward an increasing number of authors per article [2–5]. This rise in the average number of authors has been attributed in part to the increasing complexity of research, but this phenomenon of author proliferation can also be explained by the fact that scientific publication is essential for recruitment, promotion, and retention of faculty in academic medicine.

Although several studies [6–8] have examined authorship within radiologic journals, there has been no recent study assessing the current characteristics and trends in authorship. The purpose of this study was to determine authorship trends in two leading radiology journals over the past 2 decades.

Materials and Methods

This bibliometric analysis did not involve human subjects. Therefore, institutional review board approval was not required.

Data Collection

We performed a retrospective review for original research articles published during three 3-year periods (1991–1993, 2001–2003, and 2011–2013) in two U.S. radiology journals: *AJR* and *Radiology*. We chose to include these journals because they are widely circulated peer-reviewed journals with high prestige, high visibility, and strong brand-name recognition. Each journal publishes one issue per month; therefore, our study covered 216 issues (i.e., 9 years × 12 months × 2 journals).

Only original articles with a first or corresponding author affiliated with radiology, nuclear medicine, or other imaging-related departments (e.g., radiologic science, imaging center, and medical imaging) were included in the analysis. If an author had a nonradiology affiliation or if a research group was named as the first or corresponding author, the article was excluded from the analysis. Original articles considered were scientific reports that investigated clearly defined study objec-

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TABLE 1: Average Number of Authors per Article Published in *AJR* and *Radiology* for the Periods 1991–1993, 2001–2003, and 2011–2013

Journal	Mean No. of Authors			*p*
	1991–1993	2001–2003	2011–2013	
AJR	4.8 ± 2.1 (1–13)	5.9 ± 2.4 (1–22)	6.3 ± 2.4 (1–45)	< 0.0005
Radiology[a]	5.3 ± 2.5 (1–28)	6.5 ± 2.5 (1–17)	7.9 ± 3.1 (1–18)	< 0.0001
Overall	5.1 ± 2.4	6.2 ± 2.5	7.1 ± 2.9	< 0.0001

Note—Except where otherwise indicated, data are mean ± SD, with ranges given in parentheses.
[a]The mean no. of authors per article of *Radiology* was significantly greater than that of *AJR* ($p < 0.0001$ for all study periods).

tives or hypotheses and contained original data—in particular, novel methods and results. All other types of articles (e.g., case reports, review articles, pictorial essays, clinical perspectives, state of the art, editorials, letters, technical notes, quizzes, educational materials, book reviews, commentaries, news, and conference abstracts) were excluded from the analysis.

Data were extracted from each journal's website by use of a standardized data collection spreadsheet. For each article, we recorded the journal name, publication year, number of authors, radiologic subspecialty (i.e., field), and country of origin. The radiologic subspecialty of each article was assigned to one of the following fields: abdominal, breast, cardiac, chest, genitourinary (including the retroperitoneum and obstetrics), musculoskeletal (including the spine), neuroradiology/head and neck, pediatric, vascular/interventional, or miscellaneous (not conforming to one of the aforementioned categories, e.g., whole-body imaging, nuclear medicine, physics, basic science, radiation oncology, contrast media, and radiation protection). We also recorded the country of origin of study for each article. For articles arising from collaboration between more than one country, the country of the first author was considered to be the country of origin of the article. If the first author had affiliations with more than one country, then the country of origin was determined to be that of the corresponding author.

To guarantee the reliability of data collection, three radiologists initially reviewed the same 200 articles independently to ensure consistency of data abstraction. After a discussion to resolve inconsistencies, all articles were divided into three samples and manually reviewed by investigators. Questionable cases were decided by the consensus of all the study investigators.

Data Analysis

Data were collected and entered into a spreadsheet by use of Excel (version 11.0, Microsoft). For the current study, we adopted a descriptive research approach based on a bibliometric analysis. The primary outcome was the mean number of authors per original article published in *AJR* and *Radiology*. After ascertaining that the data were normally distributed, we compared the mean number of authors between journals, study periods, radiologic subspecialties, and countries. Articles were divided into three groups according to the number of authors—those with one to four, five to seven, and eight or more authors—and these groups were used for further analysis of authorship. The mean number of authors per article for each country was compared with that found for Switzerland (6.3), which was the closest to the overall mean (6.2).

The differences in the number of authors per article were evaluated for statistical significance using ANOVA. Categoric variables were compared between groups by use of the chi-square test (or Fisher exact test, where appropriate). Statistical software (SPSS Statistics, version 19.0 for Windows, IBM) was used for descriptive and statistical analyses. Statistical significance was defined as $p < 0.05$.

Results

A total of 5688 original articles were published in *AJR* and *Radiology* during the three study periods. Among these, 493 (8.7%) articles in which both the first and corresponding authors were affiliated with nonradiology departments were excluded; therefore, 5195 articles were included in the final analysis (*AJR, n* = 2468; *Radiology, n* = 2727). There were 1468 articles in 1991–1993, 1860 in 2001–2003, and 1867 in 2011–2013. For the two journals combined, the mean number of authors per article increased from 5.1 in 1991–1993 to 6.2 in 2001–2003 and to 7.1 in 2011–2013 ($p < 0.0001$) (Table 1). Both *AJR* and *Radiology* had statistically significant increases in the number of authors per article over the study period ($p < 0.0005$ and $p < 0.0001$, respectively), but the number of authors per article in *Radiology* was significantly higher than that in *AJR* ($p < 0.0001$ for all study periods). In addition, the proportion of articles with one to four authors decreased from 44.2% to 14.5% whereas the proportion of articles with eight or more authors increased from 14.6% to 31.5% between 1991–1993 and 2011–2013 ($p < 0.001$) (Table 2).

Table 3 shows the average number of authors per article by radiologic subspecialty. All radiologic subspecialties showed statistically significant increases of authorship over the three time periods analyzed.

There were considerable variations between countries in the number of authors per article. The mean numbers of authors per article from Italy (8.3, $p < 0.0001$), Japan (7.6, $p < 0.0001$), France (7.5, $p < 0.0001$), Germany (7.4, $p < 0.0001$), China (7.3, $p < 0.005$), Austria (7.2, $p < 0.005$), and South Korea (6.8, $p < 0.05$) were significant higher

TABLE 2: Distribution of Articles Published in *AJR* and *Radiology* According to the Number of Authors

Journal and No. of Authors	No. (%) of Articles			*p*	
	1991–1993	2001–2003	2011–2013	1991–1993 vs 2001–2003	2001–2003 vs 2011–2013
AJR				< 0.0001	0.176
1–4	293 (48.2)	277 (31.8)	181 (18.3)		
5–7	254 (41.8)	392 (45.1)	674 (68.1)		
≥ 8	61 (10.0)	201 (23.1)	135 (13.6)		
Radiology				< 0.0001	< 0.0001
1–4	356 (41.4)	203 (20.5)	90 (10.3)		
5–7	350 (40.7)	500 (50.5)	334 (38.1)		
≥ 8	154 (17.9)	287 (29.0)	453 (51.7)		
Total				< 0.0001	< 0.0001
1–4	649 (44.2)	480 (25.8)	271 (14.5)		
5–7	604 (41.1)	892 (48.0)	1008 (54.0)		
≥ 8	215 (14.6)	488 (26.2)	588 (31.5)		

TABLE 3: Average Number of Authors per Article Published in *AJR* and *Radiology* by Radiologic Subspecialty

Subspecialty	Mean No. of Authors			*p*
	1991–1993	2001–2003	2011–2013	
Abdominal	5.4	6.5	7.6	< 0.001
Breast	4.3	5.8	6.9	< 0.001
Cardiac	6.0	6.5	8.4	< 0.001
Chest	5.1	6.6	7.5	< 0.001
Genitourinary	5.1	6.3	7.0	< 0.001
Musculoskeletal	4.7	5.4	6.5	< 0.001
Neuroradiology/head and neck	5.2	6.3	7.1	< 0.001
Pediatric	4.4	5.4	6.7	< 0.001
Vascular/interventional	5.5	6.1	7.1	< 0.001
Miscellaneous	5.2	6.1	6.3	< 0.001

TABLE 4: Average Number of Authors per Article Published in *AJR* and *Radiology* by Country of Origin

Country of Origin	Mean No. of Authors	*p*
Australia (*n* = 29)	5.3	< 0.05
Sweden (*n* = 20)	5.5	0.1421
Canada (*n* = 189)	5.5	< 0.01
United States (*n* = 2852)	5.6	< 0.05
Turkey (*n* = 23)	5.7	0.2892
United Kingdom (*n* = 160)	6.0	0.4520
Switzerland (*n* = 115)	6.3	—[a]
Belgium (*n* = 51)	6.5	0.6464
Israel (*n* = 25)	6.5	0.6511
Taiwan (*n* = 38)	6.7	0.2582
Spain (*n* = 28)	6.7	0.3541
The Netherlands (*n* = 131)	6.7	0.1084
South Korea (*n* = 323)	6.8	< 0.05
Austria (*n* = 89)	7.2	< 0.005
China (*n* = 98)	7.3	< 0.005
Germany (*n* = 258)	7.4	< 0.0001
France (*n* = 185)	7.5	< 0.0001
Japan (*n* = 356)	7.6	< 0.0001
Italy (*n* = 104)	8.3	< 0.0001

Note—Only countries that had more than 20 articles published over a 9-year period were included. Number. of articles published is given in parentheses.
[a]The mean number of authors per article in each country was compared with that for Switzerland (6.3), which was closest to the overall mean (6.2).

when compared with that for Switzerland (6.3), which was the closest to the overall mean. In contrast, the mean numbers of authors from Australia (5.3, $p < 0.05$), Canada (5.5, $p < 0.01$), and the United States (5.6, $p < 0.05$) were significantly lower than that that for Switzerland (Table 4).

Discussion

Many previous studies have showed an established trend toward a substantial proliferation of authorship in journals of medicine and the health sciences [2–5]. This increase is also evident within the field of radiology. Chew [6] reported that the mean number of authors listed in articles (all categories) published in *AJR* and *Radiology* increased from 1.8 in 1950 to 4.4 in 1985. Mussurakis [8] evaluated authorship patterns in 12 leading radiology journals and described an increase in the mean number of authors listed on articles (including original articles and case reports) from 2.2 in 1966 to 4.4 in 1991. After examining over 5000 original articles published in *AJR* and *Radiology* during the past 2 decades, we found a similar trend: the number of authors per article significantly increased in both journals.

The continued increase in the number of authors for scientific articles may be attributed partially to the increasing complexity of research and an increased need for collaboration among researchers. In the present study, the mean number of authors for articles published in *Radiology* was significantly higher than that in *AJR* during all study periods analyzed. The reason for this difference is not clear, but it may reflect that articles published in journals with higher impact have more complex study design, have more collaborative efforts, and therefore have more authors.

Another contributing factor to increasing authorship must undoubtedly be the increased pressure to publish more articles. Promotions, prestige, tenure, salary, and grant funding have long been associated with prolific publishing in peer-reviewed journals [9, 10]. Consequently, the "publish or perish" [11] environment of medical academia increasingly leads to pressure to grant "honorary authorship" (i.e., to individuals who do not fulfill the authorship criteria) [12]. Previous surveys [13, 14] have confirmed that the prevalence of honorary authorship tends to be higher for articles with a greater number of authors.

There have been attempts to preserve the value of authorship and to prevent inappropriate author-number inflation. Some journals have since required all authors to specify their contributions to the development of the manuscript to reduce the number of honorary authors [15]. To answer the question of who should be considered an author, the International Committee of Medical Journal Editors (ICMJE; formerly the Vancouver Group) first established their criteria for authorship in 1985. The ICMJE's criteria for authorship are probably the most widely distributed definition of authorship and have been adopted by many prestigious medical journals, including *AJR* and *Radiology* [16]. In the latest revision of "Defining the Role of Authors and Contributors" [17], the ICMJE recommended that authorship should be based on meeting all four of the following criteria: substantial contributions to the conception or design of the work or the acquisition, analysis, or interpretation of data for the work; drafting of the work or revising it critically for important intellectual content; final approval of the version to be published; and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. In addition, some journals have proposed their own guidelines and have applied rules limiting the maximum acceptable number of authors per manuscript.

One reason why journals require signed declarations of authorship contribution is to reduce the prevalence of honorary authorship. According to our results, however, the introduction of the required author-contribution forms by *AJR* and *Radiology* (since 1985) did not stop the trend toward increasing authorship. Using the number of authors as a surrogate marker for inappropriate authorship, we did not find indirect evidence that this strategy has worked well until re-

cently to keep honorary authors off the list. Moreover, despite standards and procedures designed to curb inappropriate assignment of authorship, recent studies indicate that the prevalence of honorary authors in radiologic publications ranged from 17% to 52% [14, 18–20]. The prevalence of honorary authorship in *AJR* increased from 17% in 1992–1993 [14] to 25% in 2003–2010 [20], based on original articles published in *AJR*.

We were particularly interested in the authorship trend in *AJR* from 2001–2003 to 2011–2013, because the journal began limiting the number of authors of original articles to seven as of the May 2005 issue [21]. In contrast, *Radiology* has not limited the number of authors per article. Our results showed that *AJR* had a slight increase (6.8%, from 5.9 to 6.3) in the average number of authors per article from 2001–2003 (before the limitation was enacted) to 2011–2013 (during limitation), as compared with *Radiology* (21.5%, from 6.5 to 7.9). In addition, although no statistically significant difference was found, the prevalence of articles in *AJR* that exceeded the limitation (with eight or more authors) decreased from 23.1% in 2001–2003 to 13.6% in 2011–2013. These data suggest that the authorship limitation had a partial inhibitory effect on the number of authors. This disappointing result is because the required maximum number of the authors can be exceeded under special circumstances if authors provide additional justification to explain the direct participation and contributions of additional authors.

Nevertheless, despite implementation of authorship guidelines and enforced limits on the number of authors, inappropriate authorship proliferation may be difficult to prevent. However, identifying the trend toward increased authorship may be helpful for members of the radiology community (e.g., authors, institutions, and journal editors) in developing a more practical and effective authorship system. Authors should take personal responsibility to adhere to the criteria for authorship specified by individual journals or the ICMJE [22]. Moreover, academic institutions should arrange educational courses in accordance with the updated authorship guidelines [23]. Additionally, appointment and promotion committees and funding agencies should develop practical review mechanisms to identify inappropriate authorship and should adapt their publication assessment criteria from quantitative to qualitative evaluation [15, 24].

Another important implication of our findings is that a significant geographic variation in authorship may exist. Articles published in Italy and Japan, for example, had more authors than those from other countries (Table 4). A similar result was observed by Hama and Kusano [25], who examined the number of authors for abstracts from the 1999 Radiological Society of North America Scientific Assembly. They found that the percentages of multiauthor presentations (more than six authors) from Japan and Germany were significantly higher than those from North America (United States and Canada). However, there is no obvious reason for this geographic variation. Although cultural factors—workplace culture and customary practice—may indeed come into play, it is unclear from our data whether geographic and cultural factors had an effect on the rate of perceived honorary authorship. We assumed that traits of collectivism or fellowship in population could affect the increase in the number of authors per article.

In Italy, there has been anecdotal evidence of familism and favoritism, defined as the practice of favoring members of a closely knit network on the basis of family or professional ties, respectively, independent of their actual qualifications. These pervasive traditional cultures in academia may have had negative effects on appropriate authorship [26, 27]. Some investigators [28, 29] have commented that the Japanese practice of *nemawashi* (literally laying the groundwork), a semiformal but systematic and sequential consensus-building procedure, may play an important role in authorship attribution in Japan. Nevertheless, the practice of crediting numerous coauthors is not unique to Italy and Japan; the same results were found in other countries.

We acknowledge several limitations of our study. First, this study was focused on two general radiology journals with high impact; thus, they may not be representative of all journals in the discipline. Second, we evaluated only 9 years of published articles (1991–1993, 2001–2003, and 2011–2013); thus, sampling error may have influenced the results. Third, our study did not assess the characteristics of research (i.e., type of study, collaboration, funding), and there could be possible associations between these characteristics and the increasing number of authors per article.

In conclusion, our results showed significant authorship proliferation in two leading radiology journals over the past 2 decades. Author contribution disclosure requirements and limitations on the acceptable number of authors per manuscript did not abate the trend toward an increasing number of authors.

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