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Original Article

Correlation Between the Number of Authors and Citation Indicators in Iranian Systematic Reviews and Meta-Analyses Articles in Medical Sciences Indexed in Web of Science

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Abstract

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Introduction: Conducting systematic reviews and meta-analyses necessitates scientific collaboration. There appears to be a correlation between the number of authors and the number of citations. This study explores the relationship between the number of authors and the citation metrics of Iranian systematic reviews and meta-analyses in the medical sciences field.

Methods: This study is correlational in nature. It examines a research population consisting of 5,231 Iranian articles focused on systematic reviews and meta-analyses within the medical sciences. These articles were published between 2011 and 2020 and are indexed in the Web of Science database. The articles were identified using relevant keywords related to systematic reviews and meta-analyses in the advanced search section, utilizing the TS tag. The evidence was sourced from Articles and Reviews. The analysis utilized SPSS software version 29, employing descriptive statistics along with the Shapiro-Wilk and Spearman tests to analyze the findings.

Results: The number of articles featuring multiple authors has grown over the years. Most articles analyzed (62.7%) had between three and six authors. The peak average number of authors occurred in 2014, reaching 12.4 per article. A growing trend is visible in terms of average citations based on the age of the articles. The average number of authors per article does not correlate significantly with the citation indicators examined in the article.

Conclusion: The primary trend observed in the articles examined was a shift towards increased scientific collaboration. While no significant correlation was observed between the average number of authors and citation indices, the overall findings suggest that more authors tend to be linked with a higher number of citations.

Introduction

The evidence-based medicine approach involves the thoughtful, clear, and thorough application of evidence to guide patient healthcare decisions. Rather than relying on a single study, clinical decisions are based on a comprehensive evaluation of all relevant

evidence (1, 2). Systematic review and meta-analysis articles, among various types of studies, hold special importance due to their valuable role in evidence-based medicine (1-3) and are positioned at the highest level of the evidence hierarchy (4-6). A systematic



review article in the medical sciences results from a qualitative study that aims to answer one or more clinical questions by using explicit and reproducible systematic search methods, critical appraisal, and synthesis of the results of primary studies. In these studies, the results from several related primary studies are combined using strategies that reduce biases and random errors. The statistical analysis of the results from systematic review studies leads to a meta-analysis (5-7). If systematic review studies and meta-analyses are conducted appropriately, they produce reliable evidence for decision-making in the field of evidence-based practice. For this reason, the Cochrane Institute has centered its mission on producing this valuable evidence (8). In Iran, the production of these articles is also supported by Cochrane Iran (9). Given the increasing importance of evidence-based medicine and, consequently, the growth of systematic review and meta-analysis articles (6, 7), examining the indicators related to the production and publication of these articles, including authorship characteristics and citation metrics, can lead to the generation of valuable information.

Multiple factors can influence the citation metrics of articles, including systematic review and meta-analysis papers. In a comprehensive systematic review study, Tahamtan et al. identified 28 components that affect the number of citations (10). Researchers have divided these factors into three main categories. The first category focuses on elements related to the article, including scientific quality, novelty, and topic appeal. It also considers the characteristics of the research field, study design and methodology, document type, and the structure of the results and discussion.

Additionally, it looks at using charts and appendices, features of the title and abstract, references, article length, publication date, initial citation count, and the article's accessibility and visibility. The second category relates to the characteristics of the journal, such as impact factor, publication language, specialized scope, and publication format. The third category pertains to the authorship characteristics, including the number of authors, their reputation and academic rank, the extent of self-citation,

national and international collaborations, country of activity, gender, age, race, scientific productivity, organizational affiliation, and access to financial resources. The results of this study confirm that the number of authors, along with factors such as article quality, journal impact factor, visibility, and international collaborations, play a strong predictive role in increasing citations (10). Scientific collaborations, and the resulting increase in the number of authors, play a crucial role in conducting systematic reviews and meta-analyses. While a search of PubMed up to August 2021 reveals that 3,035 systematic review articles by single authors have been published, and there was an upward trend in such publications from 2000 to 2020 (11), there is serious doubt about the feasibility of conducting these studies solo (12). Some experts argue that having at least three researchers collaborate is essential for effectively carrying out these studies (13). The Cochrane Handbook also explicitly states that more than one author is needed to compile a systematic review (14).

Systematic reviews and meta-analyses often garner significant citations, making it intriguing to explore if the number of authors influences the citation count these articles receive. Shahbodaghi et al. analyzed the authorship characteristics of 9,579 systematic review and meta-analysis articles from Iran, published between 2011 and 2021, and indexed in Scopus as part of a broader study. In this study, one of the authorship characteristics examined was the number of authors per article and the average number of authors per article based on the year of publication; however, the researchers did not investigate the relationship between the number of authors and citation indicators (15). Talaat et al. conducted a study examining the relationship between the number of co-authors and the number of citations received by 629,814 articles. The data for this study were obtained from the AI-based research platform AMiner (<https://www.aminer.cn>), developed by Tsinghua University in China with the aim of providing advanced tools and data for analyzing scientific networks. One of the essential datasets of this platform used in this research is the Citation Network Dataset, providing extensive

information about scientific articles and authors and their citation relationships (16). Soheili et al., aiming to examine the factors influencing the number of citations of articles in the library and information science, conducted a study using a mixed-methods approach (quantitative-qualitative). The study population included 70 Iranian experts in the qualitative phase and 1,665 articles indexed in the quantitative phase in the Web of Science (WoS) and LISA databases. The research method was mixed (qualitative-quantitative). In the qualitative phase, the Delphi technique was used to identify and weight 70 influential factors in five main groups (research field characteristics, journal, article, author, and keywords). In the quantitative phase, citation analysis and statistical tests such as Kendall and Spearman correlation were applied (17). In another study, Abramo et al. examined the relationship between the number of authors and the number of citations of articles, as well as the impact factor of the journals publishing them. This study analyzed 392,257 articles indexed in the WoS, published by Italian researchers between 2004 and 2010 (18). Wuchty et al. also examined 19.9 million scientific articles from the ISI WoS database and 2.1 million patents from 1955 to 2000 in the fields of science and engineering, social sciences, arts, and humanities to find the relationship between the size of the author team and the citation metrics of the articles. They also studied this relationship in highly cited papers (articles with more than 1,000 citations) (19). Jaksic et al. also examined 88,594 articles in the field of health to find the relationship between the number of authors and citation indicators, including individual and collective self-citation (20). A review of the above studies showed that no study has yet investigated the relationship between the number of authors and citation indicators of systematic review and meta-analysis articles.

In this study, an attempt has been made to examine the authorship characteristics and citation indices of Iranian systematic review and meta-analysis articles in the field of medical sciences indexed in the WoS database, as well as to examine the relationship between the number of authors and the citation indices of the articles. The findings of this

study can provide valuable information to planners, policymakers, and other research stakeholders at all levels, as well as researchers interested in conducting systematic reviews and meta-analyses, to understand the quantity and quality of the path taken and to design the path ahead.

Methods

The population studied in this study is all Iranian systematic review and meta-analysis articles in the field of medical sciences indexed in the WoS database between 2011 and 2020 (5231 articles were found in the retrieval on 2/7/2021). The keywords systematic review and meta-analysis were first searched from the WoS database using the topic tag to reach the research population.

TS= ("systematic review*") OR TS= (meta-analysis) OR TS= ("meta-analysis") OR TS= (meta-analyses) OR TS= ("meta-analyses")

After initial retrieval, the results were limited to Iran using WoS facilities from 2011 to 2020. In the next step, the results were analyzed based on WoS subject categories, and those subject categories of articles covered by the US National Library of Medicine (NLM) classification (21) were selected. In the final step, the results were limited to Review regarding document type (in the search on 2/10/2021, 5231 articles remained). After the research population was determined, the process of extracting data from the research population began. Initially, the number of authors per article was identified based on the year of publication. Next, the average number of authors for each year was calculated. Subsequently, the database was used to extract the number of citations for these articles by the year of study. This allowed for the calculation of the average number of citations per article, as well as the average number of citations per year, considering the total number of articles published each year. In the next step, by extracting the Hirsch index of articles from the database, the average Hirsch index was calculated and determined based on the age of the articles and the number of articles, as well as the percentage of articles above the Hirsch index threshold. The last step tested the relationship between the average number of authors per article and the calculated citation indices. The

findings were analyzed using WoS tools, Excel, and SPSS software, employing descriptive and analytical statistics. Correlation analysis was also performed to evaluate the relationship between the number of authors and citation indices. First, the normality of the distribution of the study variables was examined using the Shapiro-Wilk test. Spearman's correlation coefficient was used due to the non-normal distribution of the variables. These statistical methods were used to quantify the power and the relationship between variables. Notably, given that at the time of data collection, less than a year had passed since the publication of the 2020 articles and these articles did not have enough time to attract citations, this year's data was discarded for hypothesis testing, and hypothesis testing was performed based on data from 2011 to 2019 on 3,642 articles published in these years. All statistical analyses related to hypothesis tests were performed using SPSS software version

29 at a significance level of 5%.

Results

The research findings have been arranged and presented in Tables 1 and 2 to show the status of the number of authors of the articles examined. According to the findings in Table 1, the number of articles resulting from collaborations with more than one author has been increasing over time. Furthermore, the most significant number of articles examined (62.7%) were written by three to six authors, and a single author wrote the smallest number (1.2%).

Table 2 reveals that the highest average number of authors per article was 12.40 in 2014, while the lowest was 12.5 in 2011. Overall, the data on the average number of authors per article over the years shows no clear pattern or trend, whether increasing or decreasing.

Table 1. Frequency of the number of authors in the Iranian systematic review and meta-analysis articles in medical sciences

Year	Number of authors				Total of authors
	Single author	Two authors	Between 3 to 6	More than six	
2011	2 (4.2%)	9 (18.8%)	30 (62.5%)	7 (14.6%)	48
2012	4 (4.2%)	12 (12.6%)	58 (61.1%)	21 (22.1%)	95
2013	9 (6.5%)	14 (10.1%)	83 (60.1%)	32 (23.2%)	138
2014	7 (4.2%)	15 (8.9%)	98 (58.3%)	48 (28.6%)	168
2015	7 (2.7%)	24 (9.1%)	177 (67.3%)	55 (20.9%)	263
2016	4 (1.0%)	32 (8.0%)	254 (63.8%)	108 (27.1%)	398
2017	7 (1.3%)	35 (6.3%)	363 (65.8%)	147 (26.6%)	552
2018	3 (0.4%)	55 (7.1%)	494 (63.8%)	222 (28.7%)	774
2019	10 (0.8%)	61 (5.1%)	789 (65.5%)	345 (28.6%)	1205
2020	12 (0.8%)	88 (5.5%)	933 (58.7%)	556 (35.0%)	1589
Total	65 (1.2%)	345 (6.6%)	3279 (62.7%)	1541 (29.5%)	5230

Table 2. Average number of authors per article in Iranian systematic reviews and meta-analyses in medical sciences

Year	Number of the articles	Number of the authors	Average authors per article
2011	48	246	5.12
2012	95	709	7.76
2013	138	724	5.24
2014	168	2084	12.40
2015	263	2024	8.07
2016	399	3205	8.21
2017	552	3705	6.71
2018	774	5998	7.74
2019	1205	7604	6.31
2020	1589	11244	7.07
Total	5231	37543	7.18

Table 3 reveals some intriguing insights into citation trends. In 2014, articles received the highest average citations per article, at 46, while 2020 saw the lowest at 40.5. When evaluating average citations based on the age of articles, 2020 leads with an average of 4295 citations, whereas 2011 records the lowest at 163. However, considering the average citations adjusted for the number of articles, 2015 comes out on top with 6.17,

and 2020 is at the bottom with 2.7. Examining the growth trend of these citation metrics shows no clear pattern in average citations per article. However, when looking at average citations adjusted for the age of articles, there is a generally upward trend, despite some fluctuations. However, when considering the number of articles, the variations are so pronounced that it is challenging to identify a consistent increasing or decreasing trend.

Table 3. Average citation of Iranian systematic review and meta-analysis articles in medical sciences

Year	Number of the articles	Number of citations	Average citations per article	Article lifespan until 2021	Average citations by article age	Average citations based on the age of articles and number of articles
2011	48	1793	37.35	11	163	3.4
2012	95	3551	37.37	10	355.1	3.74
2013	138	5836	42.28	9	648.4	4.7
2014	168	7728	46	8	996	5.93
2015	263	11365	43.21	7	1623.57	6.17
2016	399	9133	22.88	6	1522.16	3.81
2017	552	12127	21.96	5	2425.4	4.39
2018	774	13863	17.91	4	3465.75	4.48
2019	1205	10595	8.79	3	3531.67	2.93
2020	1589	8590	5.40	2	4295	2.7
Total	5231	82585	15.79	-	-	-

Table 4. The H-index of Iranian systematic review and meta-analysis articles in medical sciences

Year	Number of the articles	The article's lifespan until 2021	H- index	The average H-index based on the lifespan and number of the articles	The percentage of the articles above the H-index threshold
2011	48	11	21	0.039	43.75%
2012	95	10	33	0.035	34.74%
2013	138	9	41	0.033	29.71%
2014	168	8	44	0.032	26.19%
2015	263	7	46	0.025	17.49%
2016	399	6	46	0.019	11.53%
2017	552	5	44	0.016	7.97%
2018	774	4	47	0.015	6.07%
2019	1205	3	34	0.009	2.82%
2020	1589	2	30	0.009	1.89%
Total	5231	-	96	0.039	-

Table 4 reveals that the total Hirsch index for the 5,231 analyzed articles is 96. When looking at publication years, 2018 holds the highest Hirsch index at 47, while 2011 has the lowest at 21. However, an average Hirsch index was calculated since the raw Hirsch index does not effectively compare citation statuses across different years. This index considers the age of the articles and the number published each year. By this measure, 2011 leads with the highest average index of 0.039, while 2019 and 2020 tie for the lowest at 0.009. Additionally, examining the percentage of articles surpassing the annual Hirsch index threshold provides further insight. In 2011, 43.75% of the articles exceeded their year's Hirsch index horizon, compared to only 1.89% of articles in 2020 achieving the same feat.

Due to the non-normal distribution of the average number of authors per article, which was not normal ($p\text{-value} < 0.05$), we used Spearman's correlation coefficient to explore the relationships between various variables. Table 5 presents the

results, showing the relationship between the average number of authors per article and the following: average citations per article, average citations considering the age of articles and the number of articles, and the average Hirsch index based on the age of articles and the number of articles. The Spearman's correlation coefficients for these relationships were 0.248, 0.442, and -0.152, respectively, with corresponding p-values of 0.489, 0.200, and 0.676. Since the p-values are greater than 0.05, these relationships are not statistically significant, indicating no meaningful correlation between the variables. Despite the lack of statistical significance, the data in Table 5 suggest a trend: the average number of authors per article shows a positive relationship with both the average citations per article and the average citations based on the age and number of articles. Conversely, a negative relationship existed with the average Hirsch index when considering the age and number of articles.

Table 5. Spearman correlation coefficient between the average number of authors and citation indices

Variables	Correlation coefficient	P-value
Average citations per article / Average number of authors	0.248	0.489
Average citations based on the age of articles and number of articles / Average number of authors	0.442	0.200
Average H-index based on the age of articles and number of articles / Average number of authors	0.152	0.676

Discussion

This study investigated the correlation between the number of authors and citation indices of Iranian systematic review and meta-analysis articles in medicine and related sciences published between 2011 and 2020 and indexed in WoS.

The present study's findings confirm that three to six authors wrote most articles reviewed, and the lowest number was single-authored. Shahbodaghi et al., in a study conducted on Iranian systematic review and meta-analysis articles indexed in Scopus, showed that a few articles were single-authored (15). This could be due to the characteristics of systematic review and meta-analysis studies, making it questionable whether they can be conducted by a single author (12) and require at least three researchers to collaborate (13). Although some researchers' searches in PubMed have shown that as of August 2021, 3035 systematic reviews with one author have been published, and the number of single-author systematic reviews has been increasing between 2000 and 2020 (11). However, the Cochrane Handbook explicitly states that more than one author is required to conduct a systematic review (14). Nevertheless, Wu et al. noted that small and large teams are essential for the science and technology ecosystem to flourish. These researchers suggest that research policies should be adopted to support diversity in team size in the preparation of scientific works (22).

According to the present study's findings, the number of articles that result from the collaboration of more than one author has been increasing over time. In the study of Shahbodaghi et al., the increase in the number of authors over time, with a certain amount of ups and downs, is also evident (15).

In a well-cited study by Wuchty et al. analyzing 19.9 million articles and 2.1 million patents, they showed that knowledge production has increasingly depended on teamwork, so that in all scientific fields (basic sciences, engineering, social sciences and even arts and humanities), as well as in patent registration, the share of team articles has increased significantly (19). Waltman highlighted in his review that science is becoming more collaborative, with studies showing an increase in the average number of authors per publication (23). This trend aligns with the findings of the current study. While the growing number of authors, particularly in systematic reviews and meta-analyses, often suggests more effective scientific collaborations—an advantage widely recognized—there are also notable challenges. Some research highlights concerns about research misconduct, such as guest and honorary/gift authorship (24, 25). Two studies have reported the prevalence of such misconduct in author team selections within the medical field (26, 27). Additionally, another study mentioned complaints about external pressures in determining author teams (28). Thus, while the observed increase in collaborative authorship of systematic reviews and meta-analyses may reflect the researchers' growing practical awareness of the benefits of teamwork, it may also prompt questions about the degree of genuine contribution and professionalism in some multi-authored papers. Therefore, further studies are recommended to investigate the underlying factors contributing to the increasing number of authors in such publications.

The findings of the present study showed that no statistically significant correlation was observed between the average number of authors per article

and the average citation per article, the average citation based on the years of the articles' age and the number of articles, and the average H-index based on the years of the articles' age and the number of articles. However, despite the lack of statistical significance, the results indicated a positive (direct) relationship between the average number of authors per article and both citation-based metrics. According to the study by Talaat et al., a strong positive and significant relationship was found between the number of authors and the number of citations received by the articles. These findings were confirmed by Pearson correlation analysis, using multiple regression, and the use of a probabilistic neural network. These researchers have stated that, of course, in addition to the number of authors, this relationship may also be affected by other factors such as the quality of the journal, the year of publication, and the geographical spread of the authors (16). In a study conducted by Abramo et al., examining articles by Italian researchers indexed in WoS, they also concluded that in all subject areas studied, there is a significant and consistent linear growth between the ability to attract citations of the articles under review and the number of their authors (18). Soheili et al. have also reported a strong relationship between the number of authors and the number of citations received by library and information science articles (17). Tahamtan et al. have also pointed out three categories of factors that affect the number of citations in their research. Article-related, journal-related, and author-related factors are categorized under 28 factors. These researchers have classified the number of authors as one of the factors related to the number of citations, under the category of author-related factors (10). The results of Wuchty's study also indicate that team research receives more citations, such that even in the production of highly cited research (such as articles with more than 1000 citations), teams have replaced individual researchers. They have shown that this trend remains valid even without considering self-citations. The study shows that the transformation in the knowledge production from the traditional model of single authorship to collaborative teamwork has been widespread, encompassing all the academic

disciplines examined (19). A study by Yang et al. showed that if this team collaboration is gender diverse, it can attract more citations. By studying 6.6 million articles published in more than 15,000 different medical journals worldwide, they found that mixed-gender teams produce more innovative and highly cited articles than all-female or all-male teams (29). A comprehensive study by Jaksic et al. on 88,594 articles in the health field also showed that although there is a positive relationship between the number of authors and the number of citations of articles, this relationship is mainly due to an increase in collective self-citations rather than actual citations made by other researchers. The findings reveal that the correlation between the number of authors and collective self-citations (0.31) is notably stronger than the correlation with citations from others (0.23). Specifically, self-citations rose from 10.6% in single-author articles to 34.8% in those with over 50 authors. This suggests that the surge in citations in multi-author papers may be more about expanding a network of colleagues and increasing collective self-citations, rather than indicating higher scientific quality. As a result, it is recommended that scientific evaluations consider removing collective self-citations from indices like the h-index to offer a clearer picture of an article's scientific impact (20).

In general, the lack of a significant relationship between the average number of authors per article and the citation indices studied could be influenced by various factors. These include issues like gift authorship, guest authorship in the author team, a narrow subject focus in the core articles, poor quality of evidence, the evidence not addressing the health system's needs, and a low rate of collective self-citation due to professional reasons. These are possible factors, but more research is needed to understand their scientific implications better.

Conclusion

This study investigated the correlation between the number of authors and citation metrics of systematic reviews and meta-analyses conducted by Iranian researchers in medicine and related sciences. The data comprised articles published between 2011 and 2020 indexed in the WoS database. The findings



indicate a dominant trend toward teamwork in producing systematic reviews and meta-analyses during the study period. This trend aligns with the results of various studies showing a general shift in scientific research toward collaborative efforts. This increase likely reflects a growing recognition of the benefits of scientific collaboration; however, further research is recommended to better understand the underlying factors driving this trend.

Additionally, the study found no statistically significant correlation between the average number of authors per article and citation-related metrics, including average citations per article, average citations adjusted for article age and volume, and average h-index normalized by article age and count. Although not statistically significant, the overall pattern suggested a positive association: Articles with more authors tended to receive more citations. In contrast, several previous studies have reported a strong and direct relationship between author count and citation impact. Other variables may have influenced this study's results and warrant further investigation. It is also recommended that future research employ alternative statistical methodologies or larger datasets to uncover better patterns in the relationship between author count and citation metrics in Iranian-authored articles indexed in various databases, across different scientific disciplines, and over longer timeframes.

Declaration

Acknowledgment

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Conflict of Interest

There is no conflict of interest in this study.

Ethical Statement

This study was conducted using the ethical approval code IR.SBMU.RETECH.REC.1400.004, obtained from the Ethics Committee for Biomedical Research at Shahid Beheshti University of Medical Sciences.

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Authors' Contribution

- Mohammad Reza Hatami: Responsible for data collection and analysis, and provided final approval.
- Azam Shahbodaghi (Corresponding Author): Led study design and methodology, involved in data collection and analysis, wrote, reviewed, and edited the manuscript, supervised the project, and gave final approval.
- Maryam Shekofteh: Contributed to study design and methodology, reviewed the manuscript, and granted final approval.
- Reza Taherian: Participated in data analysis and gave final approval.

Use of Artificial Intelligence

AI-based software was used to identify sources and translate texts into English.

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