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A grey zone for bibliometrics: publications indexed in Web of Science as anonymous

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Abstract
Publications without authorship information have been indexed as anonymous in the Web of Science database over the years. However, discussions on this subject have not been sufficiently addressed in the scholarly literature. Since bibliometrics studies are widely used for bibliometricians, scientific disciplines, science policy, and management, missing significant data as authorship metadata characterizes a gray zone that directly impacts these three components, and by extension, for bibliometrics and scientometrics. With a data collection performed at Web of Science Core Collection (WoSCC), 1,420,842 documents under "anonymous" authorship from 1900 to 2021 were retrieved, which accounted for 1.5% of the total documents indexed in the WoSCC. The publication data such as yearly growth of research publications, document type, language, productive research areas, and other bibliometric indicators were analyzed. The findings showed that in absolute numbers, a considerable growth of anonymous publications between 1996 and 2009, and there was a downward trend after that. However, this increase has not been proportional to the growth in the total number of publications indexed in the WoSCC. Articles, editorial materials, and news items were the top three document types among the WoSCC-indexed publications as anonymous. This study also finds two main scenarios of indexing publications as anonymous. The first is associated with the historical context of scholarly communication and practices that persist. The second is characterized by indexing persistent problems. This study suggests minimizing the error in databases, enabling an error-free indexing system and accurate bibliometrics studies.

Keywords Anonymous author · Unknown author · Indexing · Web of Science · Publications

Mathematics Subject Classification 00-02

JEL Classification C00

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Introduction

The main task of bibliographic databases is indexing publications (e.g., articles, books, conferences). Each record in databases contains metadata repositories such as the author's name, title, year, publisher, author's keywords, and keywords that the publishers provide. The "author field"—designated for the entry of author metadata—is one of the essential items in indexing work, especially in document retrieval. For this reason, citation databases such as Scopus and Web of Science (WoS) have separate fields for entering this metadata. However, sometimes these metadata are incompletely indexed or left empty, thus reducing the chances of retrieving documents required by users. Such a defect by Web of Science Core Collection (WoSCC) as the world's leading scientific citation search and analytical information platform (Li et al., 2018) is mentioned: "Articles with no stated authors are indexed in the Web of Science Core Collection as Anonymous" (Clarivate, 2022a, 2022b). WoSCC now has nearly 80 million documents, while an initial search of anonymous documents in the database reveals over 1.4 million records, which is more than 1.5 percent of the total WoSCC indexed documents. The number is substantial and worth considering for further examination. Although it is impossible to determine anonymous authors' identities, studying their publications in the literature can throw a new light on these publications' characteristics. As Pritchard (1969) stated, "bibliometrics is the application of mathematical and statistical methods to books and other media of communication". Thus, bibliometric methods and tools have been employed for deciphering the publication patterns and characteristics widely over the years.

Throughout the years, issues related to scientific authorship have been received scholarly attention in various domains (Bebeau & Monson, 2011; Claxton, 2005a, 2005b; Cronin, 2001; Hagen, 2010; Matheson, 2011; McNutt et al., 2018; Ni et al., 2021; Paneth, 1998; Rennie & Flanagin, 1994; Wilcox, 1998). However, discussions about anonymous authorship among a core of themes (Hosseini & Gordijn, 2020) have been rarely reported. This lack of critical attention to this matter is perhaps a "paradoxical consequence" of anonymous publication, as Paku (2015) argues.

Bibliometrics studies are widely used for bibliometricians, scientific disciplines, science policy and management (Bornmann & Marewski, 2019; Glänzel & Schoepflin, 1994). We argue that published or indexed scientific documents as anonymous characterize a grey zone for bibliometrics and scientometrics. To the best of our knowledge, no research to date has empirically investigated the problem of missing author information on databases. Thus, we aim to explore this problem by using the Web of Science Core Collection as an information source to reduce inattention to this matter.

Theoretical background

Indexing

An index is a list of publications within a discipline and subject in library science, which provides bibliographic information, such as author names and publication titles (Florida Atlantic University Libraries, 2022). The bibliographies assist researchers in locating publications and determining the relevance to research topics. Indexes have traditionally been provided in print, but more are in electronic form with the development of information

technology. Electronic indexes are widely used in the library field as databases to locate information published by academic and commercial publishers, such as dissertations and academic articles (Florida Atlantic University Libraries, 2022). Web of Science is a multidisciplinary bibliometric citation database covering medical, scientific, and social science journals with its purpose to integrate citation indexes and provide a broad space for indexing and citation analysis (Ramlal et al., 2021). It contains records from multiple bibliographic databases, such as Science Citation Index Expanded (SCI-Expanded) and Social Sciences Citation Index (SSCI) (Haraldstad & Christophersen, 2015). The WoS is often used to search for topics and cited references. For instance, it retrieves articles cited by a reference article and helps view references cited in relevant articles. Articles in the database can be searched by authors' names, country, title, and source (Ramlal et al., 2021).

Authorship metadata

Brand et al. (2003) defined metadata as "information about information or, equivalently, data about data" (p. 1). In the context of academic research, metadata such as author, date, title, subject, language, and the identifier is the fundamental component that accompanies all research stages to complete daily scientific research tasks and the core of ensuring the research products meet the external requirement (Gregg et al., 2019; Mayernik, 2019). Its stakeholders include "researchers, funders, publishers, librarians, systems and service providers, and data curators" (Gregg et al., 2019, p. 1). Flynn (2013) pointed out that of all the stakeholders, the calls to improve metadata quality frequently fall on publishers and expect them to sort out the product information provided to vendors to create higher quality records, thus benefiting individuals who use the services. The flawed semi-automated metadata collection techniques used by vendors and publishers could omit the core information of academic products (Flynn, 2013). For instance, Bull and Schultz (2018) revealed that the lack of ISSNs as standard metadata causes librarians to be unable to determine the status of access restrictions. Demetrescu et al. (2018) investigated author names' accuracy status as reported in bibliographic records.

The author's name is one of the essential elements in scholarly communication in the current digitization era. As Gasparyan et al. (2016) described, indexers of databases first process an author's name and then link to his/her articles when the articles were indexed. Correct spelling of author names make it convenient to record academic work and achieve scholarly communication (Gasparyan et al., 2016). However, false author names occasionally appear in academic publications (Demetrescu et al., 2018; Gasparyan et al., 2016; Neuhaus & Daniel, 2008). As Tunger et al. (2010) revealed in their study, the bibliometric data error rate was near 7%, and the citation error rate was 15%, indicating the same percentage of publications that cannot be retrieved in the database. Even though the errors caused by the inaccurate author's name-related metadata in extensive scale literature evaluation studies were negligible, they have significant negative impacts on bibliometry-based expert identification, recruitment decisions, and career development from individual researchers (Olensky, 2015).

In addition, omitting authors' names influenced the publication of academic articles. For instance, Simcoe and Waguespack (2011) found that the publication rate of scholars with high academic status declined significantly when they concealed their names with et al. Missing author names in literature also occasionally occurs (Gupta, 2021). To solve the problem, Zhuang et al. (2005) proposed the feasibility of quoting crawling technology nearly two decades ago to collect missing metadata in array library collections.

Bibliometrics has been applied to identify document forms that are most used, for instance, authorship patterns in the field and publication trends (Arya & Sharma, 2011; Hussain et al., 2011; Thanuskodi, 2010). Scholars from various disciplines, such as agriculture (Niknejad et al., 2021; Wei et al., 2020), chemistry (Kamdem et al., 2019; Kato & Ando, 2013; Thanuskodi, 2010), and medicine (Demir et al., 2020; Michalopoulos & Falagas, 2005; Tran et al., 2019), use bibliometrics to explore scientific developments in their fields by collecting articles from academic journals, databases, and university repositories.

Few studies have applied bibliometrics to analyze missing academic author metadata. Liu et al. (2018) explored the articles without authors' addresses indexed publications in WoS. They stated that the address information was the foundation of various bibliometric analyses to investigate collaborations across organizations, countries, and regions. Ignoring the missing information could lead to inaccurate findings and confusion (Liu et al., 2018). Authors' names are more critical than addresses. However, there is a lack of relevant studies using bibliometrics to analyze authors' names in the current literature.

Methods

Data sources and searches

As one of the most reliable publisher-independent global citation databases in the world, Web of Science™ Core Collection (WoSCC) was chosen as an information source for this study (2022a, 2022b). To search for anonymous indexed records, the term "Anonymous" was entered by selecting the "Author" field in WoSCC (Clarivate, 2021). The period 1900 to 2021 was included to retrieve the full range of these documents. The following indices were searched for the WoSCC: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI. The survey was conducted during the last week of January 2022. All findings were extracted in Excel format.

Bibliometric parameters

The following bibliometric parameters were extracted for further analysis: (a) access types, most prevalent (b) document types, (c) publishers and journals, (d) research areas, (e) countries and publication languages, and the (f) most and highly cited documents.

Results

The search returned 1,420,842 results from 1900 to 2021. Although the absolute numbers of publications indexed as anonymous have increased over time, this increase has not been proportional to the growth in the total number of publications indexed in the WoSCC. As shown in Fig. 1, the number of publications indexed under anonymous authorship (in blue in Fig. 1) relative to the total (in orange in Fig. 1) has decreased dramatically over this historical series. For example, while in 1900, there were 1025 anonymous documents for every 10,000 publications, by 2021, this number had decreased to 43 for every 10,000 publications.

Summarizing the type of access of these documents and considering the information available in the database, 28,434 were published under Open Access license (OA), 5247

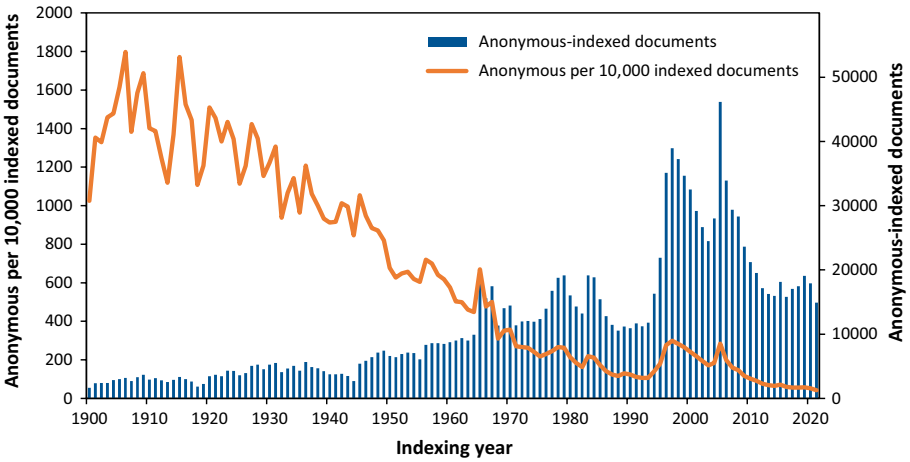

Fig. 1 Time evolution of documents indexed as anonymous in the WoSCC

under green OA, 3714 under Gold OA, 761 under gold-hybrid OA, and 21,795 were free to read. We also noticed 2633 green submitted documents and 829 green accepted documents.

Document types

Figure 2 shows the most prevalent document types indexed as "anonymous" in WoSCC. Among the 46 types of documents indexed, including the four new document types, and considering possible overlapping classifications, our survey identified 45 document types indexed as anonymous,—within the corpus of 1,420,842—missing only "publications with expression of concern". We note the prevalence of articles ($n = 331{,}912/24\%$) followed by editorial materials, usually unsigned, since they represent the journal's opinion

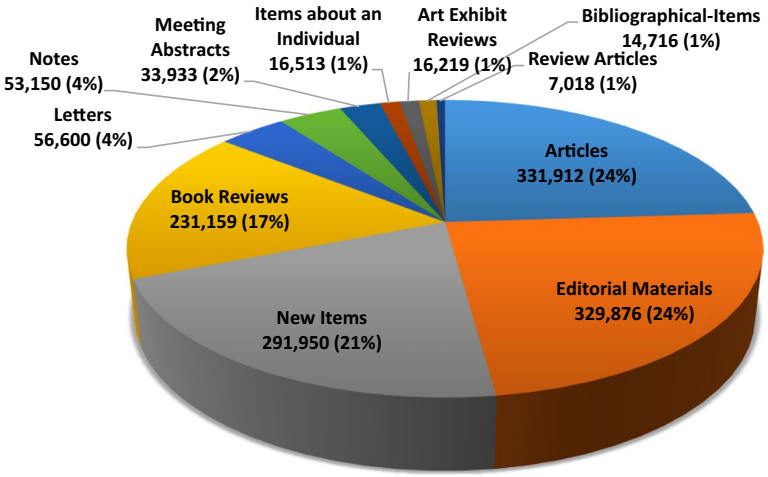

Fig. 2 Most prevalent document types indexed as anonymous in the WoSCC

(*n* = 329,876/24%), news items (*n* = 291,950/21%), book reviews (*n* = 231,159/17.0%), letters (*n* = 56,600/4.0%), notes (*n* = 53,150/4.0%), meeting abstracts (*n* = 33,933/2.0%), items about an individual (*n* = 16,513/1.0%), art exhibit reviews (*n* = 16,219/1.0%), bibliographical-items (*n* = 14,716/1.0%), and review articles (*n* = 7018/1.0%).

Publishers and journals

Table 1 summarizes the Top 10 publishers and journal names that lead the ranking of publications indexed as anonymous in association with the most prevalent types of documents. These publishers accounted for 381,305 documents. Of these, 75,682 documents (20.0%) were indexed under *Elsevier* terms, followed by *Springer Nature* (*n* = 67,694/18.0%), *Wiley* (*n* = 58,899/15.0%), *BMJ Publishing Group* (*n* = 45,417/12.0%), *American Chemical Society* (*n* = 36,038/9.0%), *American Medical Association* (*n* = 28,793/8.0%), *Lancet Ltd* (*n* = 22.013/6.0%), *Lippincott Williams & Wilkins* (*n* = 17,588/5.0%), *Kluwer Academic Publishers* (*n* = 15,634/4.0%) and *Oxford University Press* (*n* = 13,447/3.0%).

By analyzing the main document types as a function of the top 10 publishers, most documents published by *Elsevier* (44.0%), *Springer Nature* (35.0%), *BMJ Publishing Group* (60.0%), and *American Medical Association* (50.0%) refer to editorial materials documents.

As for the publishers *Kluwer Academic Publishers* (63.0%), *Lancet Ltd* (55.0%), *Lippincott Williams & Wilkins* (30.0%), *Oxford University Press* (21.0%), *Wiley* (20.0%), and *American Chemical Society* (13.0%), most of the entries were articles. Only Wiley had published art exhibit reviews (1.0%).

Table 1 also shows the top 10 Journals with the most WoSCC-indexed publications as anonymous. This core is composed with prestigious journals in different domains with high Impact Factor (ranging from ~ 69.5 to 202.7), such as *The Lancet* (*n* = 45,421/20.0%), *Nature* (*n* = 36,416/16.0%), *BMJ-British Medical Journal* (*n* = 25,411/11.0%), and *JAMA* (*n* = 16,287/7.0%). Analyzing these journals as a function of the most prevalent document types can provide a better understanding. For instance, most of the records found for *JAMA* (76.0%), *Nature* (61.0%), and *The Lancet* (54.0%) consist of editorial materials, which are usually intentionally unsigned. On the other hand, the *BMJ* sample has 61.0% referring to articles indexed as anonymous with 30.0% of editorial materials.

Research areas

Regarding the research areas (Table 2), also considering possible overlapping classifications, "Engineering" (*n* = 240,064/28.0%) and "General Internal Medicine" (*n* = 166,087/20.0%) ranks the first and second positions. When we consider the WoSCC categorization of areas, "Medicine General Internal" takes first position (*n* = 164,334/28.0%) and "Engineering Chemical" is highlighted among the engineering disciplines (*n* = 81,813/14.0%).

Countries

According to the data available in WoSCC, 56 countries were found. United States of America (U.S.) accounted for most indexed anonymous publications in the database (*n* = 351/42.0%). Considering the top 10 countries, co-occurrences can also be found in Italy (*n* = 60/7.0%), Germany (*n* = 50/6.0%), England (*n* = 45/6.0%), Brazil (*n* = 44/5.0%),

Table 1 Top 10 Publishers and Journals in association with the most prevalent types of documents

Category	Prevalent document types (%)							
	Articles	Editorial materials	New items	Book reviews	Notes	Meeting abstracts	Art exhibit reviews	Review articles
Publisher								
Elsevier	18.0	44.0	16.0	7.0	6.0	8.0	0.0	1.0
Springer Nature	32.0	35.0	17.0	6.0	1.0	7.0	0.0	2.0
Wiley	20.0	13.0	22.0	36.0	1.0	6.0	1.0	1.0
BMJ Publishing Group	10.0	60.0	24.0	2.0	2.0	1.0	0.0	1.0
American Chemical Society	13.0	6.0	74.0	1.0	4.0	1.0	0.0	1.0
American Medical Association	30.0	50.0	10.0	3.0	4.0	2.0	0.0	1.0
Lancet Ltd	55.0	30.0	3.0	4.0	6.0	1.0	0.0	1.0
Lippincott Williams & Wilkins	30.0	22.0	20.0	18.0	2.0	7.0	0.0	1.0
Kluwer Academic Publishers	63.0	2.0	2.0	24.0	7.0	1.0	0.0	1.0
Oxford University Press	21.0	12.0	20.0	19.0	3.0	18.0	0.0	7.0
Journal name								
The Lancet	30.0	54.0	2.0	3.0	8.0	2.0	0.0	1.0
Nature	32.0	61.0	2.0	1.0	2.0	1.0	0.0	1.0
Chemical & Engineering News	9.0	2.0	81.0	1.0	4.0	1.0	0.0	2.0
BMJ—British Medical Journal	61.0	30.0	2.0	1.0	2.0	1.0	0.0	3.0
JAMA—J Am Med Assoc	11.0	76.0	6.0	0.0	3.0	2.0	0.0	2.0
Veterinary Record	2.0	32.0	61.0	2.0	1.0	1.0	0.0	1.0
Economist—Netherlands	67.0	0.0	0.0	26.0	7.0	0.0	0.0	0.0
Connaissance des Arts	3.0	2.0	16.0	14.0	4.0	0.0	59.0	1.0
New Scientist	6.0	71.0	20.0	0.0	3.0	0.0	0.0	0.0
Public Health Reports	88.0	2.0	4.0	2.0	2.0	3.0	0.0	1.0

Table 2 Top 10 research areas and Web of Science core collection categories

	n	%
Research area		
Engineering	240,064	28.0
General internal medicine	166,087	20.0
Science technology other topics	76,226	9.0
Chemistry	72,680	9.0
Business economics	65,232	8.0
Government law	63,130	7.0
Materials science	56,227	7.0
Veterinary sciences	38,429	4.0
Public environmental occupational health	37,045	4.0
Food science technology	32,614	4.0
Web of Science category		
Medicine general internal	164,334	28.0
Engineering chemical	81,813	14.0
Multidisciplinary sciences	72,226	12.0
Chemistry multidisciplinary	46,679	8.0
Veterinary sciences	38,429	7.0
Economics	38,216	7.0
Public environmental occupational health	37,045	6.0
Law	33,977	6.0
Food science technology	32,614	6.0
Engineering electrical electronic	32,540	6.0

France ($n=27/3.0\%$), Japan ($n=27/3.0\%$), Canada ($n=20/3.0\%$), Australia ($n=17/2.0\%$), and China ($n=13/2.0\%$), as shown in Fig. 3. The collection of the least prevalent 45 countries are listed in Table A1 (Online Resource 1).

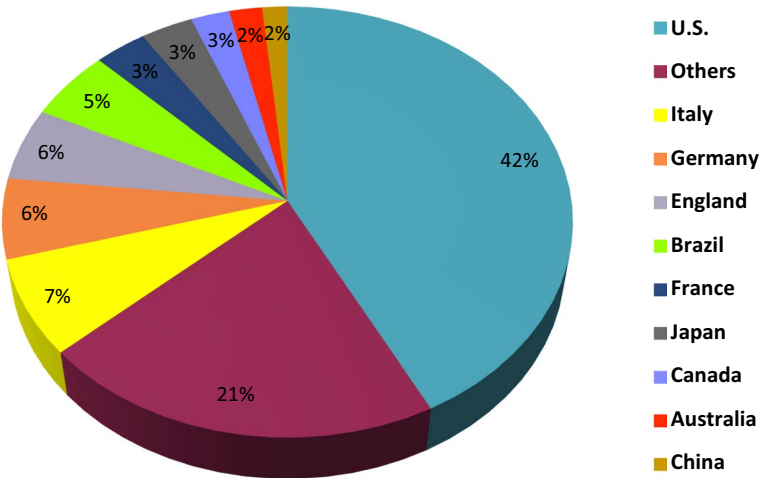

Fig. 3 Top 10 countries that published documents indexed as anonymous in the WoSCC

Publication languages

As shown in Fig. 4, English ($n=1,242,292$) is the prevalent language among the corpus, as this is the standard language adopted by most publishers, followed by German ($n=72,042$), French ($n=60,926$), Russian ($n=8775$), Italian ($n=8762$), Spanish ($n=7485$), Dutch ($n=3533$), Polish ($n=2386$), Japanese ($n=1810$), and Swedish ($n=1414$). In total, 49 different entries for language typing were found in the WoSCC.

Also considering language classification overlap in WoSCC, the "other" classification (Fig. 4) includes, in addition to unspecified ($n=97/0.006\%$), multiple languages ($n=529/0.037\%$), and others ($n=9.090/0.036\%$). Further languages are listed in Table A2 (Online Resource 1).

Most cited and highly cited papers

As shown in Table 3, articles (34,505 total citations), reviews (6484 total citations), and editorial material (4557 total citations) were the mostly document types responsible for the top 20 most cited papers—cumulatively, the number of citations reaches 45,546.

Unsurprisingly, the majority (60%) of the most cited articles were published four decades ago, with the earliest in 1980. Thus, to reduce some of the biases associated with raw citation count, the "highly cited" categorization available in the WoSCC was also included in this analysis. All of the top 10 most cited and the top 10 highly cited papers indexed as anonymous in the WoSCC were from the medical sciences. One paper was identified in both categorizations—"Standards of Medical Care in Diabetes-2012". The number of publication citations was less relating to the journal impact factor. Instead, it was more relevant to the publication topics. For instance, among the top 10 most cited and the top 10 highly cited publications, five were related to pulmonary function and respiration, and four were related to myocardial infarction. The findings may be explained by the impact of social context (e.g., COVID-19 pandemic) on scientific research. Also, the World Health Organization (2020) pointed out that the leading cause of human death globally level includes ischemic heart disease (whose symptoms include

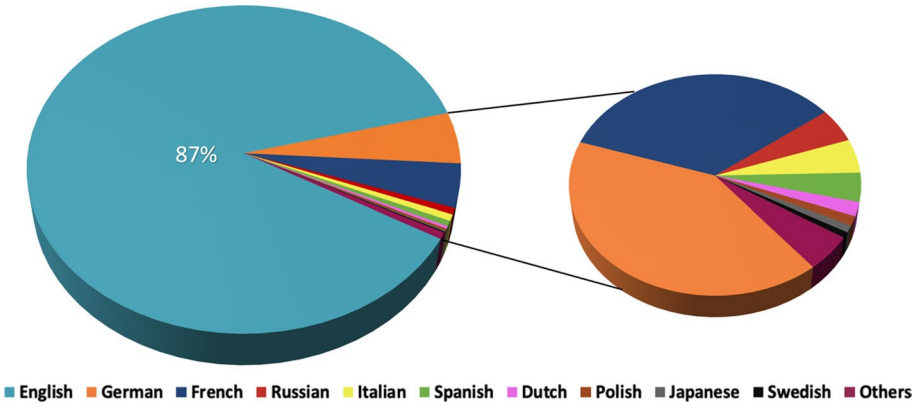

Fig. 4 Top 10 Languages identified in the published/indexed documents as anonymous in the WoSCC. English ($n=1,242,292/87.019\%$), German ($n=72,042/5.046\%$), French ($n=60,926/4.267\%$), Russian ($n=8775/0.614\%$), Italian ($n=8762/0.613\%$), Spanish ($n=7485/0.524\%$), Dutch ($n=3533/0.247\%$), Polish ($n=2386/0.167\%$), Japanese ($n=1810/0.126\%$), and Swedish ($n=1414/0.099\%$)

Table 3 Top 10 most cited and top 10 highly cited papers indexed as anonymous authorship in the WoSCC

	Journal name (JIF 2021)	Year	Document type	Times cited
Most cited—article title				
Standardization of Spirometry—1994 Update	American Journal of Respiratory and Critical Care Medicine (30.528)	1995	Article	5456
Randomized Trial of Intravenous Streptokinase, Oral Aspirin, Both, or Neither Among 17,187 Cases of Suspected Acute Myocardial-Infarction—ISIS-2	The Lancet (202.731)	1988	Article	5054
Proposal for Revised Classification of Epilepsies and Epileptic Syndromes	Epilepsia (6.74)	1989	Editorial Material	4557
Guidelines for the Management, of Adults with Hospital-acquired, Ventilator-associated, and Healthcare-associated Pneumonia	American Journal of Respiratory and Critical Care Medicine (30.528)	2005	Review	4451
Preliminary Criteria for the Classification of Systemic-sclerosis (Scleroderma)	Arthritis and Rheumatism (NF)	1980	Article	3684
Preliminary-report—Effect of Encainide and Flecainide on Mortality in a Randomized Trial of Arrhythmia Suppression After Myocardial-infarction	New England Journal of Medicine (176.079)	1989	Article	2798
Standards of Medical Care in Diabetes-2012	Diabetes Care (17.152)	2012	Article	2404
Effectiveness of Intravenous Thrombolytic Treatment in Acute Myocardial-infarction	The Lancet (202.731)	1986	Article	2079
Lung-function Testing—Selection of Reference Values and Interpretative Strategies	American Review of Respiratory Disease (NF)	1991	Review	2033
Standards for the Diagnosis and Care of Patients with Chronic Obstructive Pulmonary-disease (COPD) and Asthma	American Review of Respiratory Disease (NF)	1987	Article	1986
Highly cited—article title				
Standards of Medical Care in Diabetes-2012	Diabetes Care (17.152)	2012	Article	2404
Fourth universal definition of myocardial infarction (2018)	Revista Española de Cardiología (6.975)	2019	Article	2369
Classification and Diagnosis of Diabetes	Diabetes Care (17.152)	2015	Article	1838
2020 Alzheimer's disease facts and figures	Alzheimers & Dementia (16.655)	2020	Article	947

Table 3 (continued)

	Journal name (JIF 2021)	Year	Document type	Times cited
EASL-ALEH Clinical Practice Guidelines: Non-invasive tests for evaluation of liver disease severity and prognosis	Journal of Hepatology (30.083)	2015	Article	899
Introduction (https://doi.org/10.2337/dc17-S001)	Diabetes Care (17.152)	2017	Article	784
Scientific Working Group for Forensic Toxicology (SWGTOX) Standard Practices for Method Validation in Forensic Toxicology	Journal of Analytical Toxicology (3.22)	2013	Article	514
The 2012 Hormone Therapy Position Statement of The North American Menopause Society	Menopause (3.31)	2012	Article	455
Diagnosis and Treatment Protocol for Novel Coronavirus Pneumonia (Trial Version 7)	Chinese Medical Journal (6.133)	2020	Article	417
The Diagnosis and Treatment of Peripheral Lymphedema: 2013 Consensus Document of The International Society of Lymphology	Lymphology (2.325)	2013	Article	417

JIF Journal Impact Factor (according to the Journal Citation Reports 2022), *NF* Not found. (Data accessed on June 29th, 2022).

myocardial infarction) and respiratory infections, which may explain the publications on this topic on the top 20 list. One of the publications included in the highly cited papers list—"Diagnosis and Treatment Protocol for Novel Coronavirus Pneumonia (Trial Version 7)"—, Released by the *National Health Commission & National Administration of Traditional Chinese Medicine*, was related to Coronavirus Disease 2019 (COVID-19).

Discussion

At first glance, by utilizing a set of 121 years of documents indexed as anonymous in the authorship metadata of WoSCC ($n = 1{,}420{,}842$), in absolute numbers, our results point to a rising trend in these records over the years. However, as previously stated, this increase has not been proportional to the growth in the total number of publications indexed in the WoSCC (Fig. 1). The highest number of indexed articles as anonymous comprises the interval between 1994 and 2012, with the first peak in 1997, declining until 2003 when it begins to rise again. Other minor local peaks were observed previously, in 1965, 1979 and 1983. The peak of records in the entire historical series was identified in 2005, reaching a value higher than 46,000 indexed documents without authorship information in a single year. After that, these records dropped again, stabilizing in the last ten years, with values below 20,000 documents, around the first historical maximum value, recorded in 1965.

The current study findings identified two main scenarios of indexing publications as anonymous. One is publishing under anonymous authorship—associated with the historical context of scholarly communication and the practices that persist and, therefore, are related to intentional action. The other one is characterized by indexing persistent problems which result in imprecise metadata in WoSCC and may be related to an unintentional action. The latter one implies the considerations argued in the introduction and literature sections.

The core of anonymous publications in prestigious journals in WoSCC, such as *The Lancet* ($n = 45{,}421/21\%$) and *Nature* ($n = 36{,}416/16\%$), is composed of editorial materials, usually unsigned since they represent the journal's opinion (24% in our findings, as mentioned above) and does not fit into the scenarios presented herein. Smith (1999, p. 5) has stated that "*anonymous editorials in scientific journals were common a decade ago; now they look anachronistic*." Lock (1981) argued that anonymity in editorials allows opinions that are not popular to be voiced. Thus, only opinions are criticized, not the author. By contrast, Smith (1994) points out secondary conflicts of interest in unsigned editorials, as he reports in a case that occurred in the *British Medical Journal*. Garfield (1998) characterized this behavior as "provincial" and as a ploy to increase authority to the opinions expressed. Pondering pros and cons, Smith et al. (2006) argued that avoiding anonymity in editorials can improve transparency and accountability for the ideas published. Similarly, by advocating that transparency when signing opinions in editorials overcomes any disadvantage, Smith (2006, p. 433) asks a rhetorical question: "*should anyone publish anything in the scientific literature if they are not prepared to sign their name?"* By analyzing editorials published in *Nature* and *Science* journals, Waaijer et al. (2011) found that editorials indicate driving science issues. Although unsigned editorials are tradition, since they reflect the views of the editorial board, in the name of transparency, many journals have been adopting the practice of signing editorials.

First scenario: standing on the shoulders of [anonymous] giants

Under the first scenario, papers published anonymously are usually under pseudonyms or authored by committees, research groups, and scientific societies. The article entitled *The Probable Error of a Mean* published in 1908 under the pseudonym "Student" and later ascribed to William Sealey Gosset, one of the pioneers of modern statistics, illustrates one of this praxis.

Anonymous publishing was a common practice more than four centuries ago—Thomas Hobbes, René Descartes, John Lock, Isaac Newton are examples of scientists who published their scientific communications anonymously (Hahn, 1971; Kronick, 1988; Merton, 1957). Our findings corroborate previous studies on anonymously authored articles published from remote times. Zimmermann (1979) discussed an anonymous publication, in the field of botany, in 1845, which reported the discovery of Tylose formation, whose authorship was ascribed to the Viennese baroness Hermine von Reichenbach. By using computational stylistics, Drew and Hugh (2011) aimed to identify the author of an article published anonymously in 1863 in the weekly magazine "All the Year Round" under Charles Dickens's editorship. In a recent study, Corsi (2021) analyzed three anonymous articles published between 1826 and 1829 in the *Edinburgh New Philosophical Journal*.

The results of the current study revealed that among the most cited and highly cited anonymous articles (Table 3), published in journals with Impact Factors ranging from ~ 2.3 to 202.7, all of these were authored by scientific committees, research groups, or research societies. Hahn (1971) pointed out that collective findings, such as those by the *Accademia del Cimento*, were published without citing their contributors. Historically, this period was marked by emphasizing discoveries instead of discoverers. In contrast, other reasons for using anonymity or pseudonyms added by Kronick (1988), such as to avoid pre-judgments associated with the author's identity or persecution. Whereas the premise of anonymity can be favorable to publishing articles with censored content, such as political content, or opinions that are not as popular in general (Lock, 1981), it can pose some disadvantages for transparency in science:

- Ambiguity and questions for readers may accompany articles. Sometimes the precision in describing methods, results, or minor issues in the published research may fail. In this sense, when there is no author name, the impossibility of post-publication communication can be cited as a lacuna.
- Implicit hidden interests (Smith, 1994).
- Making it impossible to establish collaborations in future research.
- Retracting an article—whether due to fraud or honest mistake—is not a burden or responsibility on the author of an anonymous article.

The tacit consensus of authorship as a marker of credit and intellectual property, priority disputes, hiring, and promotions, in the context of the reward system of science, seems to have contributed to the changing practices of authorship (Biagioli & Galison, 2003; Cronin, 2001; Kronick, 1988; Larivière et al., 2021; Merton, 1957). Given that times have changed, in general, current authorship practices in scientific writing seem to overcome the issue of anonymity in scientific publishing. As Merton (1957, p. 645) argues, "[a]nonymous givers have no place in this scheme of things. Eponymity, not anonymity, is the standard". The Committee on Publication Ethics (COPE) supports

this view by stating that "[w]riting a paper is like signing a cheque and the authors must be prepared to take the responsibility" (https://publicationethics.org/case/can-scientific-paper-be-published-anonymously). In this context, considering the complexity of research performed collaboratively, guidelines, such as Contributor Roles Taxonomy (CrediT), have been used as a device to promote transparency, credit, and authorship accountability (McNutt et al., 2018). By 2018, CrediT had been implemented by over 120 journals (Allen et al., 2019), and in 2019 Elsevier announced the use of the approach for 1200 journals.

Second scenario: missing authorship metadata as a grey zone for bibliometrics

Looking beyond the scenario mentioned in the previous section, we found completely (Fig. 5a) or partially (Fig. 5b) missing metadata in WoSCC, probably related to mistakes

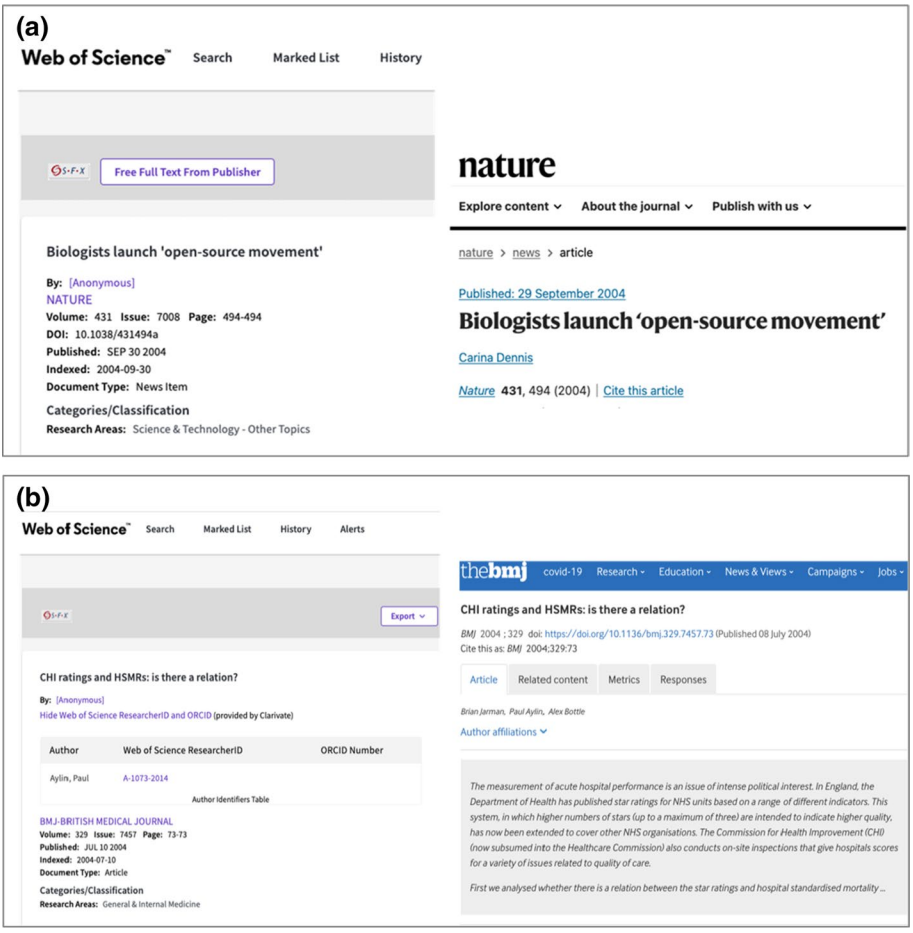

Fig. 5 Examples of **a** completely and **b** partially missing data. On the left, screenshots show the records in WoSCC. On the right, screenshots show the publications on the journals' websites. (Data accessed on February 10th, 2022)

that led to data lacking. In other words, despite the classification as "anonymous," not all documents were published anonymously.

Of the 10 most cited and 10 highly cited publications authored by scientific committees, research groups, or scientific societies (Table 3), 11 partially or fully disclosed the names of the researchers who composed the committee members or contributed to the study. The publications continued to be indexed in WoSCC as having no authorship, such as in *Effectiveness of Intravenous Thrombolytic Treatment in Acute Myocardial-infarction* published in 1986 in *The Lancet* (Fig. 6a). Partially missing data problems were also found for the sample of official statements authored by scientific societies. Figure 6b shows an example

Fig. 6 Examples of **a** publication authored by a research group that disclosed fully the names of the researchers who composed the committee members and contributed to the study; and **b** partially missing authorship metadata. On the left, screenshots show the record in WoSCC. On the right, screenshots show the publications on the journals' websites. (Data accessed on February 10th, 2022)

of an official statement of the *American Thoracic Society* and the *Infectious Diseases Society of America* published in 2005 in the *American Journal of Respiratory and Critical Care Medicine*, whose WoSCC authorship information was incomplete.

According to Glänzel (2003), the authors' names are the most relevant information for bibliographic databases. By extension, the information is also relevant for bibliometric/scientometric research. The considerable number of documents indexed as anonymous can impact the analysis of items in bibliometric research, such as gender indicators, or in identifying scientific collaboration through co-authorship relations in a more realistic way.

Glänzel and Schoepflin (1994) point out that bibliometrics is aimed at three main groups: (1) Bibliometrics for bibliometricians; (2) Bibliometrics for scientific disciplines, and (3) Bibliometrics for science policy and management. In this reasoning, bibliography databases, such as WoS, have been widely used as a data source for bibliometric and scientometric studies. *Scientometrics* journal, for instance, currently has more than 3400 papers published between 1988 and 2021 that have "Web of Science" in their title, which means that, on average, more than a hundred studies have had published per year in this journal utilizing WoS as a data source, considering only those that mentioned the database in the title of the publication. Thus, missing significant data as authorship metadata characterizes a gray zone that directly impacts these three components cited by Glänzel and Schoepflin (1994).

To illustrate this statement more clearly, we identified some studies that used WoS (all databases) and WoSCC as a data source which pointed out some problems with anonymous authorship publications in their results. Iefremova et al. (2018) observed that in more than 11% of the articles, the authorships were anonymous when analyzing the development of biographical articles and classifying the authors by gender, thus making it impossible to classify gender in the study for this percentage. By performing a citation analysis of publications on Indigenous Knowledge indexed in the WoSCC, Sarkar et al. (2020) identified that "anonymous authors" rank the first position on the top 10 most cited authors. The same occurred in Atlasi et al.'s study (2021) when they analyzed the output of researchers and organizations on COVID-19 with a focus on endocrinology, where most of the authors on the investigated topic were anonymous. Baskaran (2020) has analyzed publication trends in the Information Management domain and identified that anonymous authors held most publications. By using the WoSCC, Elango (2017) has investigated the bibliometric characteristics of literature published in Nature Nanotechnology journal between 2006 and 2015 and identified that anonymous authors published 4.6%. Some studies excluded anonymous publications from their data source or search query. For instance, Lei and Liu (2019) and Tran et al. (2019), when using WoS to analyze the development of the Artificial Intelligence domain, excluded from their data sets publications under anonymous authorship. Abouzid et al. (2021), when analyzing research trends of vitamin D receptors, also excluded from their bibliometric analysis anonymous publications. In the same manner that Hsiehchen et al. (2015), also excluded from the search query anonymous publication when analyzing multinational teams and diseconomies of scale in collaborative research.

In this sense, our findings corroborate with the appointments given by Liu et al. (2018), by stating that ignoring missing data in bibliometric analysis can lead to inaccurate findings. Jacsó (2009), for example, states that missing information, such as the absence of country classification, can result in scale distortions.

Finally, it should be noted that, as in the previously reported studies (Franceschini et al., 2016; Liu et al., 2018; Zhu et al., 2019), the present study shows that the databases are not error-free and, as pointed out here, highlighting errors can help to promote more accurate data sources.

Conclusion

Publications on anonymous or unknown authors were very limited in scholarly literature. The sheer size of documents indexed in the WoSCC database under anonymous authorship requires an in-depth study to understand this phenomenon. In this study, we have tried to unearth the publication characteristics of anonymous authors through bibliometrics. The study provides some new insights such as peak years of anonymous authors' publications, the predominant language in which unknown authors have published frequently, and the majority of the papers on this nature have appeared in prestigious journals with high impact factors. The study suggested error-free indexing of author metadata to present author names in bibliographic databases accurately. It is also important to conduct further studies like content analysis or topic modeling of anonymous author publications to explore more facets of this subject.

Limitations

This study has four main limitations. First, this study focused on analysis in anonymous publications in WoSCC. Since each database has its coverage, analysis of documents indexed as anonymous at other databases would provide another lens on this matter. Second, due to the extensive dataset, it was not possible to present some additional analytical data, including but not limited to the average citation, citation analysis, keywords analysis, and content analysis. Third, since it was nonviable to check all the documents to find out the names of the authors on journals' website, the amount of data contradiction in WoSCC was not reported. Fourth, a significant part of these publications are composed of editorial materials. However, considering that there are two types of editorials—editorials focused on a topic of interest and presenting viewpoints, and editorials that briefly comment on publications in the issue—it was not able to draw this distinction between the two types. Moreover, future studies that do not consider this type of publication or even focus on this distinction may offer new insights.

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Data availability Data is accessible from the Web of Science Core Collection database.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

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