

## **Scholarly open access journals in medicine: A bibliometric study of DOAJ**

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# Scholarly Open Access Journals in Medicine: A Bibliometric Study of DOAJ

## Abstract

This study aims to present a quantitative analysis of open access (OA) journals in the field of medicine indexed in the Directory of Open Access Journals (DOAJ). The bibliographic data for this study was extracted from DOAJ and inserted into an Excel sheet for analysis. The retrieved data was analyzed by using different quantitative techniques to disclose the findings. The findings disclosed that 3,627 OA journals related to the field of medicine are indexed in DOAJ, which represents a substantial increase from just 8 in 2002. Moreover, most of the medical journals (n =1,874 or 51.7%) do not charge any Author Processing Charges (APC) from the authors. The United Kingdom leads the world with 878 (24%) open access journal titles, whereas English is the top language of publication with 3,149 (86.8%) OA journals in medicine. Elsevier is the leading publisher with 236 (6.5%) journal titles. A majority of the journals (n =1,595 or 44%) follow a double blind, peer-review process. About 2046 (56.4%) journals publish their contents under the Creative Commons (CC BY) licensing model to enable access and use of scholarly content for educational purposes.

**Keywords:** Medical Journals, OA journals, Directory of OA Journals, Open Access Movement, Medicine, Bibliometrics.

## Introduction

The concept of open access has created new directions within the scholarly communication system. Open access has been steadily increasing in usage because of its perceived benefits (Moskovkin et al., 2021). Scholars felt that traditional publishing had many hurdles, such as time taken to get the research published, pay per page charges, and copyright restrictions. However, OA journals have removed the barriers related to access and cost of subscription-based journals as they offer free access to their contents (Mishra & Maharana, 2020).

At the same time, the quality of OA journals has been steadily improving in reputation (reza Ghane and Niazmand, 2016). As a result, medical sciences that touch upon the varied

aspects of medication, for example, are embracing this idea. Scholars within diverse fields of medical science, such as physicians, neurologists, pathologists, and pharmacologists, are actively publishing in OA journals. This study is an effort to report on the growth and trends of medical journals within the DOAJ database. Its primary objective is to promote awareness among medical students and researchers, as well as information professionals who support the research of medical clinicians and health care professionals.

## **Literature review**

The review of the literature has been divided into several main sections to contextualize the current study. In the preliminary sections, the authors present a brief overview of the OA movement, which explores the range of applicable definitions, models, and major OA platforms, particularly the Directory of Open Access Journals (DOAJ). The principal advantages of and concerns about OA are also presented. In the final section, the authors have examined OA research in the specific area of medicine.

### *Definition of Open Access*

One of the key broad definitions of OA has been explained by the Budapest Open Access Initiative (BOAI) as “the free accessibility of articles on the public internet, allowing any users to browse, download, copy, distribute, print, search, or a link to the complete texts of those articles, crawl them for an assortment, pass them as knowledge to a software package, or use them for the other lawful purpose, while not monetary, legal, or technical barriers apart from those indivisible from gaining access to the internet itself” (Budapest Open Access Initiative, 2002).

Initially, the term “open access” was considered by researchers as removing access barriers specifically to research (Suber, 2012). However, following the launch of the BOAI, open access has come to be regarded as digital content which is available online without any restrictions regarding consent and price. In addition, digital content ranges from text, data, images, audio, video, multimedia, to executable code.

### *Open Access models*

Researchers have identified a variety of types / models of OA; these include, but are not limited to, green, gold, hybrid, diamond, bronze, and black (Piwowar et al., 2018; Open Access

Australasia, 2021). The authors have focused on those which are particularly relevant to the current study, i.e., green and gold.

Open Access Australia defines green OA as the term which is used “when the author accepted version of a published work is deposited into a subject-based repository or an institutional repository” (OAA, 2021). Gold open access, on the other hand, refers to “publishing in a fully open access scholarly journal, one where the publisher of the journal provides free and immediate online access to the full content of the journal and the final published versions of articles in that journal are fully open access” (OAA, 2021). While there are differing business models for the latter type of OA, the one which is particularly pertinent to the current study is when a publisher demands that the author pays an article processing charge (APC). This will be discussed in more detail below.

### *Directory of Open Access Journals (DOAJ)*

In addition to academic societies and commercial publishers, there are various platforms which publish OA journals, such as the Public Library of Science (PLOS), BioMed Central (BMC), and Scientific Open Access Journals (SOAJ). DOAJ is one such platform; it was launched in 2003 with only three hundred OA journals. In 2009, there were approximately 4,800 active OA journals which published about 190,000 articles. At the time, an estimated 7.7% of all peer-reviewed articles had been published in fully OA journals (Gurov et al, 2016).

Jeyapragash et al. (2016) conducted a study to investigate the journals specifically indexed in DOAJ. Their findings disclosed that although the number of OA journals was increasing in all disciplines, a majority of OA journals (29.4%) were being published in the field of medicine. English was identified as the major language used in a majority (56%) of the journals and articles. The study also highlighted the role of DOAJ in facilitating access by the research community to scholarly publishing content. In a similar study, Ramasamy et al. (2017) studied 57 OA journals on a genetic science subject that were indexed in DOAJ. They reported that the U.S was the leading country in the publication of OA journals and that English was the most highly used language of communication. Based on the findings of their study, they encouraged students, scientists, and professionals to utilize the DOAJ website to access and read the full text online journals.

Morrison (2017) claimed in her study that DOAJ represented approximately 27% of the world's scholarly peer-reviewed journals, and the article-level search encompassed about 10% of the global scholarly journal articles. Likewise, although DOAJ indexes journals in all academic disciplines, medicine was more highly represented (31%) than other disciplines. DOAJ presently indexes over 15,581 journals from 134 countries in a wide range of disciplines. DOAJ has become the preferred platform for OA journals, resulting in a substantial number of journals in its directory (Reddy & Pujar, 2021).

### *Advantages of Open Access*

Much has been written about the potential advantages of publishing in open access resources. They include, but are not limited to:

- Wider access to publicly funded scientific research
- Increased and wider readership of research content in general
- Accelerated scientific communication with the potential for maximizing new discoveries and innovation
- Increased citations for authors
- Partial solution for libraries for so-called crises of “price and permission” (Eve, 2014)

While acknowledging the relatively slow progress in achieving optimal adoption, Björk (2017, p. 252) has described open access as “almost inevitable, because it is the optimal solution, and [sic] the best interest of all stakeholders in the process”. This is particularly relevant in developing countries as academic, medical and research institutions tend to have limited resources, and libraries are not adequately funded for subscriptions to research literature (Boufaars and Laakso, 2020; Serrano-Vicente et al., 2016).

### *Concerns regarding Open Access*

Pinfield (2013) has identified a major concern as the Article Processing Charges (APC), also referred to as a “Publication Fee” (Björk & Solomon, 2012). According to Beaudry et al. (2019), in general APCs are paid through either research grants or university funds, through offsetting agreements, or, in some cases, by the authors themselves. However, these publication charges can present a serious obstacle for authors, especially from developing countries

(Fontúrbel & Vizentin- Bugoni, 2021; Greussing et al., 2020; Vuong et al., 2020; Memon, 2019; Pavan & Barbosa, 2018; Laakso & Björk, 2012).

In addition, Beall (2016) argued that although OA publishing had many benefits for the scholarly communication system, OA models were being exploited by predatory publishers. Therefore, it was extremely important for researchers to learn about these fake publishers, so as to have their research published in quality OA journals. He characterized predatory journals as those that fail to manage peer review, include spamming, and use fake metrics to trap the authors. In another study, Beall (2017) reported that for the previous ten years researchers, especially from the biomedical field, had been receiving huge numbers of spam emails from predatory publishers. In these spam emails, the editors praised previous works of the authors and invited them to submit their new manuscripts to their journals. Beall warned that the purpose of these spam emails was to trap authors and make money by exploiting the gold open access model.

### *Open Access journals in medicine*

OA journals were first widely discussed in scholarly circles in various disciplines in the late 1990s. According to Tomaszewski et al. (2013), the open access movement has existed longer within the sciences and medicine than in other disciplines, such as the humanities and social sciences. Laakso and Björk (2012, p. 1) reported that in a 10-year period, biomedicine, for example, had experienced a “particularly rapid 16-fold growth between 2000 (7,400 articles) and 2011 (120,900 articles).”

For their part, Wang et al. (2019) recently estimated that a range of OA journals in the medical sciences had risen by 500% and the number of articles by 900% throughout the previous decade, i.e., 2000-2009. The difference between the two growth measures is explained by the fact that the average yearly range of articles published per OA journal rose from around 20 to 40 during that period. Hugar (2019) has reported on the trend and growth of OA journals worldwide specifically in DOAJ. His findings also affirmed that the volume of journals in DOAJ was gradually increasing. Moreover, journals related to medicine and education were identified as the top listed journals in DOAJ. In the same year, Mousavi et al. (2019) investigated the use of Creative Commons (CC) licenses for medical science journals indexed until early 2016 in DOAJ; they reported that around 70% used a CC license. In a study limited to the CC BY

license, Ellison et al. (2019) reported that most leading medical journals do not offer this specific license to authors who are reporting commercially funded research.

In the following year, Sharma (2020) conducted a bibliometric study to analyze various aspects of DOAJ. The findings of his study revealed that the number of OA journals in English language had increased to an even greater extent and that the majority of journals were in medicine. Countries such as UK, US, Poland, and Switzerland were identified as among those which contributed most highly. This study concluded that developed countries are more advanced in research and medicine than the developing countries. However, earlier work by Husain and Nazim (2013) highlighted the challenges which the latter face in launching OA journals, e.g., continuing cultural, legal, and monetary barriers as well as gaining the acceptance of OA journals and their use.

Hansoti et al. (2016) conducted a study to differentiate between the legitimate and predatory open access journals in medicine. They reported that legitimate OA journals openly reveal publishing fees (if applicable) to authors, have rigorous peer review process, and do not charge readers. However, predatory OA journals hide any APCs, perform fake peer review, accept all submissions to generate funds, and are not indexed sufficiently to allow other researchers to find the work. They further disclosed that the number of predatory journals and publishers was expanding rapidly, which greatly threatened the integrity of scientific research. Therefore, authors and scholars needed to be aware of predatory journals when submitting their works to OA journals. More recently, Taylor (2021) has reinforced these concerns in his article published in *Pediatric Radiology*.

Rodrigues et al. (2020) have also acknowledged the issue of predatory journals and have highlighted efforts by DOAJ to attempt to address this by applying a “Seal” to identify high quality content. In their study, they have reported that the “distribution of knowledge areas is in keeping with the relative prominence of the areas in the scientific world generally, with the highest number of titles falling into the area of medicine” (p. 3). They have then examined the relationship between knowledge areas and APC amounts; medicine accounted for the most expensive titles, with “around 50% of titles charging more than US\$1,500 to publish an article” (p. 9).

In analyzing the specific contribution which OA medical journals make, Chirico (2019) has argued that public health is concerned with improving the health of people. Therefore, he emphasizes that the research findings published in medical journals should be shared with policy makers, organizations, and other researchers. Describing the story of the *Journal of Health and Social Sciences* (JHSS), which is an OA journal, he claims that it is a platform where research from developing countries is equally represented with research from developed countries. He further claims that through JHSS, research findings are freely available to everyone, which constitutes an important contribution toward addressing inequalities in access to health research.

In summary, all these studies have affirmed that the number of OA journals continues to increase within the DOAJ database, and that medicine continues to account for the highest number of titles.

## Objectives of the research

The broad objective of this study was to analyze the present status of open access (OA) journals in the field of medicine indexed in DOAJ. The specific objectives of the study were to:

- Identify the annual growth of open access medicine journals in DOAJ
- Investigate the distribution by country of OA journals in medicine
- Identify the language coverage of OA journals in medicine
- Identify the publishers that publish OA journals in medicine
- Investigate the licensing models followed by the publishers of OA journals in medicine
- Identify the peer review policy followed by the OA journals in medicine
- Identify the value of DOAJ medical journals in the current pandemic crisis

## Methods and procedures

The bibliographic data of all the OA journals in the field of medicine that was indexed in DOAJ was extracted from DOAJ on April 26, 2021 and inserted into an Excel sheet. The complete list of journals in “medicine” was obtained by using the keyword “medicine” in the “Search by Subject” function provided on the DOAJ website. The subject category of “medicine” identified a total of 3,627 OA journals indexed in DOAJ.

## Results and analysis

### *Annual growth of medicine journals in DOAJ*

The number of medicine journals in the DOAJ database has been constantly increasing over the years. The first medicine journal title was added to the DOAJ in 2002; as of 2021, the number of medicine journals had risen to 3,627. The statistics presented in Table 1 show that the annual growth pattern for the first fourteen years was initially stable but small, until 2016 when the growth increased to double digit figures. Note: The data for 2021 is incomplete as this research was conducted in 2021.

**Table 1 - Distribution of journals by year**

No	Year	No of Journals	Percentage (%)
1	2002	08	0.2%
2	2003	75	2.06%
3	2004	75	2.06%
4	2005	42	1.15%
5	2006	31	0.8%
6	2007	38	1.04%
7	2008	70	1.9%
8	2009	97	2.7%
9	2010	146	4.03%
10	2011	122	3.4%
11	2012	95	2.6%
12	2013	176	4.9%
13	2014	78	2.2%
14	2015	261	7.2%
15	2016	376	10.4%

16	2017	447	12.3%
17	2018	485	13.4%
18	2019	406	11.2%
19	2020	443	12.2%
20	2021	156	4.3%

### *Distribution of journals by country*

The findings of this study revealed that 97 countries in 2021 had contributed medicine journals to DOAJ (see Appendix A). It was found that from the top 20 countries, 878 (24%) journals are being published in the United Kingdom, 297 (8.1%) in the United States, 269 (7.4%) in the Islamic Republic of Iran, 244 (6.7%) in India, 194 (5.3%) in Brazil, 155(4.3%) in Indonesia, 125 (3.4%) in Switzerland, 113 (3.1%) in Turkey, 101 (2.8%) in the Netherlands, 97 (2.7%) in Poland, 96 (2.6%) in the Russian Federation, 94 (2.5%) in Spain, 88 (2.4%) in Korea, 55 (1.5%) in Italy, 50 (1.4%) in Ukraine, 48 (1.3%) in Colombia, 45 (1.2%) in Germany, 44 (1.2%) in Cuba, and 40 (1.1%) in both Canada and China.

**Table 2 - Distribution of journals by top 20 countries**

Rank	Country	No of Journals	Percentage (%)
1	United Kingdom	878	24%
2	United States	297	8.1%
3	Iran	269	7.4%
4	India	244	6.7%
5	Brazil	194	5.3%
6	Indonesia	155	4.3%
7	Switzerland	125	3.4%
8	Turkey	113	3.1%
9	Netherlands	101	2.8%

10	Poland	97	2.7%
11	Russia	96	2.6%
12	Spain	94	2.5%
13	Korea	88	2.4%
14	Italy	55	1.5%
15	Ukraine	50	1.4%
16	Colombia	48	1.3%
17	Germany	45	1.2%
18	Cuba	44	1.2%
19	Canada	40	1.1%
20	China	40	1.1%

It is assumed that the United Kingdom leads the world because of the OA requirements associated with its Research Excellence Framework (REF), i.e., the system for regularly assessing the quality of research in UK higher education institutions (HEI). As Rumsey (2017) explains, a commissioned report by the Working Group on Expanding Access to Published Research Findings (Finch et al., 2013) recommended that the outputs of publicly funded research in the UK should be freely accessible to increase the overall impact of research. The subsequent adoption of a REF OA policy was a “major ‘game-changer’ for most UK HEIs as it would apply to such a large proportion of research publications, not just those funded by a particular funding agency” (Rumsey, 2017, p. 58).

### *Distribution of journals by language*

According to the findings of this study, medicine journals in DOAJ have been published in 44 different languages (see Appendix B). The data presented in Table 3 shows that 3,149 (86.8%) OA journal titles in medicine are being published in the English language. The other four major languages include 342 (9.4%) in Spanish, 213 (5.9%) in Portuguese, 136 (3.7%) in

Russian, and 110 (3.0%) in Indonesian. Rankings 6 to 10 go to 85 titles (2.3%) in Persian, 72 (1.9%) in Turkish, 47 (1.3%) in Ukrainian, 41 (1.1%) in French, and 38 (1.0%) in Korean.

**Table 3 - Distribution of journals by top 20 languages**

Rank	Language	No. of Journals	Percentage (%)
1	English	3,149	86.8%
2	Spanish	342	9.4%
3	Portuguese	213	5.9%
4	Russian	136	3.7%
5	Indonesian	110	3.0%
6	Persian	85	2.3%
7	Turkish	72	1.9%
8	Ukrainian	47	1.3%
9	French	41	1.1%
10	Korean	38	1.0%
11	Polish	31	0.8%
12	Serbian	21	0.6%
13	German	20	0.5%
14	Italian	19	0.5%
15	Romanian	8	0.2%
16	Chinese	7	0.1%
17	Croatian	7	0.1%
18	Norwegian	5	0.1%
19	Slovenian	5	0.1%
20	Arabic	3	0.08%

### *Distribution of journals by publisher*

While Appendix C indicates that there are 100 publishers whose OA medicine journals are indexed in DOAJ, Table 4 provides a breakdown by the top 11 publishers, i.e., those publishers who had a percentage score  $\geq 1\%$ . Elsevier with 236 (6.5%) journal titles ranks number one, followed closely by BioMed Central (BMC) with 230 (6.3%) titles. Other publishers include 197 (5.4%) from Wolters Kluwer Medknow Publications, 134 (3.7%) from Hindawi Limited, 121 (3.3%) from SAGE Publishing, 82 (2.3%) from Wiley, 77 (2.1%) from Dove Medical Press, 54 (1.5%) from both SpringerOpen and Taylor & Francis Group, 53 (1.4%) from MDPI, and 37 (1%) from Sciendo. After that, there is a very long tail of publishers, who in aggregate actually account for nearly 90% of the titles in DOAJ.

**Table 4 - Distribution of journals by publishers**

Rank	Publisher	No of Journals	Percentage (%)
1	Elsevier	236	6.5%
2	BMC	230	6.3%
3	Wolters Kluwer Medknow Publications	197	5.4%
4	Hindawi Limited	134	3.7%
5	SAGE Publishing	121	3.3%
6	Wiley	82	2.3%
7	Dove Medical Press	77	2.1%
8	SpringerOpen	54	1.5%
9	Taylor & Francis Group	54	1.5%
10	MDPI	53	1.4%
11	Sciendo	37	1.0%

### *Peer review policies of DOAJ journals*

The journal peer review process invariably upholds standards within the review process and validates the quality of publications within journals (Tennant & Ross-Hellauer, 2020). The

findings of this study (see Figure 1) indicate that all DOAJ journals have a peer-review policy. Out of the total of 3,627 Medicine journal titles, 1,595 are following Double Blind Peer review, 1,374 titles are following Blind Peer review, 565 titles are following Peer Review, 87 have adopted Open Peer review, and 4 have an Editorial Review. One journal offers a Community and Post-Publication peer review process, i.e., published articles are made available for constructive commenting from the wider academic community.

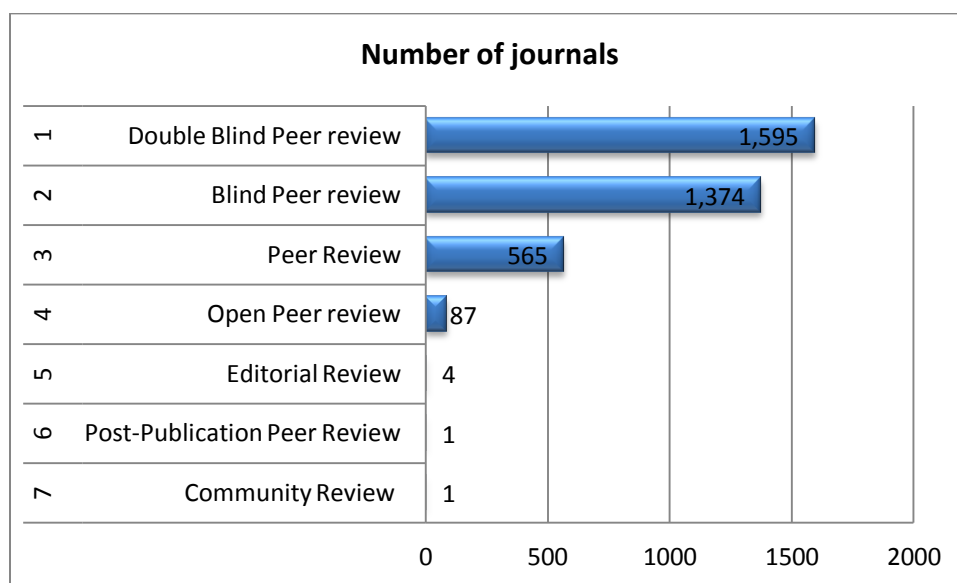


Figure 1 Peer Review Policy of Journals

### *Licensing model of journals*

A major benefit of publishing in an OA journal is that it allows the author to retain the copyright ownership of their article. For example, under the popular Creative Commons License (CC BY), articles are made freely available to all users. That is, they can access them openly, copy and reuse them for their research and study purposes. While DOAJ encourages journals to use Creative Commons licenses, it does not mandate their use. However, the directory does stipulate that licensing terms for the use and re-use of published content must be clearly stated on a journal's website.

Table 5 briefly outlines the 6 Creative Commons licenses and 1 public domain tool used by medical journals in DOAJ. The licenses have been arranged from most permissive to least permissive (Creative Commons, 2022).

**Table 5 – Creative Commons licenses**

<b>License Type</b>	<b>Description</b>	<b>Key Element(s)</b>
CC BY	This license allows reusers to distribute, remix, adapt, and build upon the material in any medium or format, so long as attribution is given to the creator. The license allows for commercial use.	Allows commercial use
CC BY-SA	This license allows reusers to distribute, remix, adapt, and build upon the material in any medium or format, so long as attribution is given to the creator. The license allows for commercial use. If you remix, adapt, or build upon the material, you must license the modified material under identical terms.	Allows commercial use Must share adaptations under the same terms as for the original license
CC BY-NC	This license allows reusers to distribute, remix, adapt, and build upon the material in any medium or format for noncommercial purposes only, and only so long as attribution is given to the creator.	Does not allow for commercial use
CC BY-NC-SA	This license allows reusers to distribute, remix, adapt, and build upon the material in any medium or format for noncommercial purposes only, and only so long as attribution is given to the creator. If you remix, adapt, or build upon the material, you must license the modified material under identical terms.	Does not allow for commercial use Must share adaptations under the same terms as for the original license
CC BY-ND	This license allows reusers to copy and distribute the material in any medium or format in unadapted form only, and only so long as attribution is given to the creator. The license allows for commercial use	Allows commercial use No derivatives or adaptations are allowed
CC BY-NC-ND	This license allows reusers to copy and distribute the material in any medium or format in unadapted form only, for noncommercial purposes only, and only so long as attribution is given to the creator.	Does not allow for commercial use No derivatives or adaptations are allowed
CC0	This tool allows creators to give up their copyright and put their works into the worldwide public domain. CC0 allows reusers to distribute, remix, adapt, and build upon the material in any medium or format, with no conditions.	This public domain tool is frequently listed separately from the 6 core CC licenses.

Figure 2 indicates the licensing models used by DOAJ journals. License types are categorized under 8 headings, of which 7 are based on Creative Commons. Out of 3,627 journals, 2,046 journals offer the CC BY license policy, 976 CC BY-NC, 805 CC BY-NC-ND, 384 CC BY-NC-SA, 205 CC0, 92 CC BY-SA, and 21 CC BY-ND. 64 use the Publisher's own license. Of the 3627 medical journals in DOAJ, the majority (56.4%) of them publish their contents under the Creative Commons (CC BY) licensing model.

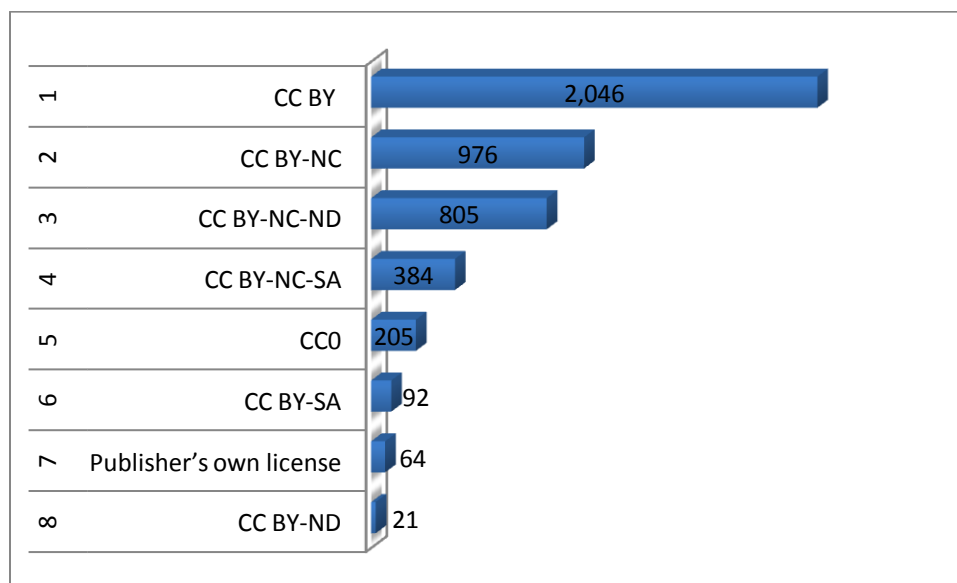


Figure 2 Journal Licensing Models

Starting with CC BY as the most heavily used license model, it is readily apparent that the next 3 types (“NC”) do not allow commercial use. Recent research conducted by Ellison et al. (2019) on OA policies of leading medical journals may help to explain this. They reported that commercially funded research constituted a large proportion of the articles published in their sample and these articles tended to be restricted in their use of a license. Therefore, in the case of DOAJ, it may be that some of its medical journals follow a similar restrictive approach.

The reason that the total number for licenses is greater than the total number of journals is because some publishers, e.g., Elsevier and Taylor & Francis, offer authors the choice of more

than one license type. In the case of *Infectious Microbes & Diseases*, for example, the publisher Wolters Kluwer Health offers authors the choice of applying any of the 6 CC licenses. DOAJ “counts” each of these separately. Therefore, a search on medical journals with license = CC BY-SA will retrieve *Infectious Microbes & Diseases* in the results; revising the search strategy to license = CC BY-ND will also retrieve the journal. However, in the results for each of the searches, the entry for the journal lists all licenses offered by *Infectious Microbes & Diseases*, i.e., all 6 Creative Commons license.

## Discussion

At time of writing, the importance of science in helping to address serious world challenges has received considerable mention in the literature (Luo, 2021; Skipper, 2021). Medicine, for example, has been highlighted for its role in times of pandemic crisis (Callaway, 2020; Duś-Ilnicka et al., 2021). However, as the editor of *CLINICS* (Moreira, 2020) has observed,

“This new situation requires scientific journals to ensure the rapid publication of existing information, but at the same time to ensure its quality and identify the potential biases and limitations of the published data. As a task force of great relevance, scientific editors must filter through the existing material, while not failing to rely on the peer review process, and must immediately deliver a response to the authors and provide resources for the publication of data. In this regard, the benefits of open access publications are obvious, especially for research in which urgency and speed are so important. Unfortunately, the proportion of new scientific research being published in open access journals is disappointingly small.”

At the same time, there is a twofold concern among researchers regarding the quality of research which may be openly accessible. On the one hand, the spread of current medical information (and misinformation) through social media happens at an alarming rate (Depoux et al., 2020). On the other hand, predatory journals have used the current desire for openly accessible medical research to increase their efforts to attract submissions (Taylor, 2021). As he observes, “Predatory journals represent a serious threat to scientific integrity because of the lack

of proper scientific review of submitted manuscripts. Publication of poor-quality research findings can lead to unsafe practices” (p. 518).

While these two phenomena may indeed be cause for concern, they also highlight the importance of DOAJ as a valuable resource to counteract their negative impact.

The objective of the current study was to report on the growth and trends of medical journals within the DOAJ database. The findings indicate that the number of these journals has been constantly increasing over the years. This substantiates research reported by Hugar (2019), Wang et al. (2019), and Sharma (2020). Likewise, the findings in the current study that English is unsurprisingly the predominant language is corroborated by all other previous research. In terms of the top contributing countries to OA medical journals in DOAJ, no other study has looked specifically at this aspect. However, the results of the current study are similar to those reported by Sharma (2020) for DOAJ as a whole. In both cases, the top 2 countries are the UK and the US.

The current study reported on the 100 publishers whose OA medicine journals are indexed in DOAJ. Elsevier with 236 (6.5%) journal titles ranks number one, followed closely by BioMed Central (BMC) with 230 (6.3%) titles. While no other study has reported specifically on this aspect, Hugar (2019) advised that the top 3 publishers in the entire DOAJ database between 2002-2018 were Elsevier (15.68%), Sciendo (15.03%), and BMC (14.25%). Sharma (2020), whose data covered 2002-2019, reported a slightly different distribution, with BMC (5.25%), Elsevier (9.90%), and Sciendo (3.98%). Thus, the current study corroborates the results of these previous 2 studies in that all 3 have Elsevier and BMC among their top 3 publishers.

Although little research has been undertaken on peer review aspects of DOAJ, the findings of this study indicate that all DOAJ journals have a peer-review policy, which is similar to results reported by Sharma (2020). Licensing in DOAJ, on the other hand, has received more attention by researchers. The current study has found that 56.4% of medical journals use the CC BY license, with less than 1% not using one of the other CC options. Mousavi et al. (2019), for their part, investigated the use of Creative Commons (CC) licenses for medical science journals indexed until early 2016 in DOAJ; they reported that around 70% used one of the 6 CC licenses. This would appear to be considerably less than the results from the current study; however,

whereas their dataset was approximately 1,000 journal titles, the current study's numbered 3,627 titles.

Ellison et al.'s study (2019) of OA policies of medical journals is useful because, as with the current study, it has reported specifically on the use of the CC BY license. While the current study has reported a usage of 56.4%, Ellison et al. reported only 36%. However, an important limitation of their research is the use of a very small sample ( $n = 35$ ), as the study only included medical journals which had a 2015 impact factor of  $\geq 15.0$ . Nevertheless, the authors make an important observation, based on their conclusion that most leading medical journals do not offer a CC BY license to authors who are reporting commercially funded research: "These restrictions hamper the further development and implementation of the approximately half of all medical research that is funded by commercial research funders" (p. 9).

In summary, on the one hand, previous research has briefly reported on medical journals as a subset either within the broader context of all OA journals or within the entire DOAJ database. On the other hand, some research has focused specifically on medical journals but within a limited context, e.g., Mousavi et al. (2019) and Ellison et al. (2019, who have reported on the use of Creative Commons licenses. Therefore, the current study is significant in that it specifically focuses on medical journals as a designated subset within DOAJ. Furthermore, it has reported on those important aspects which are normally featured in research on DOAJ content, such as top publishers, predominant language, and top countries. Finally, the study also provides detailed information about the types of peer review policies used by medical journals.

The authors believe that the findings of their current study support the overall quality of the research content in DOAJ medical journals. Consequently, they would suggest that there is a role for library research support staff in promoting DOAJ among their users. For example, DOAJ helps researchers to find appropriate publishing channels, including those which comply with their funder policies and mandates (if applicable). It ensures that their research is not submitted to a questionable or unethical journal. As a corollary, DOAJ is a source of high quality, peer-reviewed research.

## Conclusion

The Directory of Open Access Journals is one of the major and rapidly growing indexes of open access research journals; as such, it helps researchers in locating research findings within scientific literature being published around the world. DOAJ also motivates the research community to contribute their own research findings in a number of authoritative, peer-reviewed OA journals. In this article, a bibliometric study has been conducted of OA journals indexed by DOAJ in the field of medicine. Based on the findings of this study, it is concluded that a good range of OA journals on medicine are being published throughout the world, the number is constantly increasing every year, and the quality of the content makes the DOAJ database comparable with other similar commercial databases. Although many of these journals do not charge APCs, it is important to bear in mind that medicine is the discipline in which APCs are the highest. Finally, a majority of the journals are being published within developed countries, which indicates that OA journals are yet to be as popular in developing and underdeveloped countries. However, it is highly recommended that, as with any scholarly database, some of the OA journals would benefit from more rigorous editorial policies in order to publish research papers of the highest quality. In this way, they will ideally attract the attention of the academic and research community in the field of medicine.

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#### Appendix A

Rank	Country	No of Journals	Percentage (%)
1	United Kingdom	878	24%
2	United States	297	8.1%
3	Iran	269	7.4%
4	India	244	6.7%
5	Brazil	194	5.3%
6	Indonesia	155	4.3%
7	Switzerland	125	3.4%
8	Turkey	113	3.1%
9	Netherlands	101	2.8%
10	Poland	97	2.7%
11	Russia	96	2.6%
12	Spain	94	2.5%
13	Korea	88	2.4%
14	Italy	55	1.5%
15	Ukraine	50	1.4%
16	Colombia	48	1.3%
17	Germany	45	1.2%
18	Cuba	44	1.2%
19	Canada	40	1.1%
20	China	40	1.1%

21	Romania	37	1.0%
22	Australia	36	0.99%
23	South Africa	28	0.77%
24	Portugal	23	0.63%
25	Pakistan	21	0.57%
26	Serbia	20	0.55%
27	Argentina	19	0.52%
28	Mexico	18	0.49%
29	Japan	16	0.44%
30	Nepal	16	0.44%
31	Peru	15	0.41%
32	Croatia	14	0.38%
33	Greece	14	0.38%
34	Chile	13	0.35%
35	Iraq	13	0.35%
36	Paraguay	12	0.33%
37	Czechia	11	0.30%
38	Malaysia	10	0.27%
39	Hong Kong	9	0.24%
40	Norway	9	0.24%
41	Bangladesh	8	0.22%
42	Bosnia and Herzegovina	8	0.22%
43	Costa Rica	8	0.22%
44	Egypt	8	0.22%
45	France	8	0.22%
46	Sri Lanka	8	0.22%

47	Bulgaria	7	0.19%
48	Ecuador	7	0.19%
49	Saudi Arabia	7	0.19%
50	Taiwan	7	0.19%
51	Uruguay	7	0.19%
52	Lithuania	6	0.16%
53	Singapore	6	0.16%
54	Slovenia	6	0.16%
55	Venezuela	6	0.16%
56	Finland	5	0.13%
57	Ireland	5	0.13%
58	Philippines	5	0.13%
59	Slovakia	5	0.13%
60	Thailand	5	0.13%
61	Austria	4	0.11%
62	Hungary	4	0.11%
63	Sweden	4	0.11%
64	Algeria	3	0.08%
65	Belgium	3	0.08%
66	Kenya	3	0.08%
67	Republic of Moldova	3	0.08%
68	Morocco	3	0.08%
69	Nigeria	3	0.08%
70	Qatar	3	0.08%
71	United Arab Emirates	3	0.08%
72	Bolivia	2	0.05%

73	Estonia	2	0.05%
74	Kazakhstan	2	0.05%
75	North Macedonia	2	0.05%
76	Oman	2	0.05%
77	Albania	1	0.02%
78	Belarus	1	0.02%
79	Cameroon	1	0.02%
80	Congo	1	0.02%
81	Dominican Republic	1	0.02%
82	Ethiopia	1	0.02%
83	Ghana	1	0.02%
84	Guatemala	1	0.02%
85	Honduras	1	0.02%
86	Iceland	1	0.02%
87	Israel	1	0.02%
88	Kyrgyzstan	1	0.02%
89	Latvia	1	0.02%
90	Malawi	1	0.02%
91	Mali	1	0.02%
92	Mongolia	1	0.02%
93	Montenegro	1	0.02%
94	New Zealand	1	0.02%
95	Rwanda	1	0.02%
96	South Sudan	1	0.02%
97	Yemen	1	0.02%

## Appendix B

Rank	Language	No. of Journals	Percentage (%)
1	English	3149	86.8%
2	Spanish	342	9.4%
3	Portuguese	213	5.9%
4	Russian	136	3.7%
5	Indonesian	110	3.0%
6	Persian	85	2.3%
7	Turkish	72	1.9%
8	Ukraine	47	1.3%
9	French	41	1.1%
10	Korean	38	1.0%
11	Polish	31	0.8%
12	Serbian	21	0.6%
13	German	20	0.5%
14	Italian	19	0.5%
15	Romanian	8	0.2%
16	Chinese	7	0.1%
17	Croatian	7	0.1%
18	Norwegian	5	0.1%
19	Slovenian	5	0.1%
20	Arabic	3	0.08%
21	Czech	3	0.08%
22	Finnish	3	0.08%
23	Malay	3	0.08%

24	Modern Greek	3	0.08%
25	Catalan	2	0.05%
26	Danish	2	0.05%
27	Hungarian	2	0.05%
28	Japanese	2	0.05%
29	Lithuanian	2	0.05%
30	Slovak	2	0.05%
31	Afrikaans	1	0.02%
32	Belarusian	1	0.02%
33	Bosnian	1	0.02%
34	Bulgarian	1	0.02%
35	Dutch	1	0.02%
36	Galician	1	0.02%
37	Hindi	1	0.02%
38	Icelandic	1	0.02%
39	Kazakh	1	0.02%
40	Latvian	1	0.02%
41	Macedonian	1	0.02%
42	Norwegian Bokmal	1	0.02%
43	Norwegian Nynorsk	1	0.02%
44	Swedish	1	0.02%

### Appendix C

Rank	Publisher	No of Journals	Percentage (%)
1	Elsevier	236	6.5%

2	BMC	230	6.3%
3	Wolters Kluwer Medknow Publications	197	5.4%
4	Hindawi Limited	134	3.7%
5	SAGE Publishing	121	3.3%
6	Wiley	82	2.3%
7	Dove Medical Press	77	2.1%
8	SpringerOpen	54	1.5%
9	Taylor & Francis Group	54	1.5%
10	MDPI	53	1.4%
11	Sciendo	37	1.0%
12	Oxford University Press	35	0.10%
13	Frontier Media S.A.	34	0.9%
14	Tehran University of Medical Sciences	28	0.7%
15	Galenos Yayinevi	25	0.7%
16	BMJ Publishing Group	24	0.6%
17	Karger Publishers	24	0.6%
18	Termedia Publishing House	24	0.6%
19	PAGEPress Publications	22	0.60%
20	Mashhad University of Medical Sciences	21	0.5%
21	Nature Publishing Group	21	0.5%
22	Shiraz University of Medical Sciences	19	0.52%
23	Permanyer	18	0.4%
24	Wolters Kluwer	18	0.4%
25	European Medical Journal	17	0.46%
26	JMIR Publications	16	0.4%
27	Shahid Beheshti University of Medical	16	0.4%

	Sciences		
28	AOSIS	15	0.41%
29	KeAi Communications Co., Ltd.	14	0.38%
30	Adis, Springer Healthcare	13	0.35%
31	Cambridge University Press	12	0.33%
32	Thieme Medical and Scientific Publishers Pvt. Ltd.	11	0.30%
33	ABV-press	10	0.27%
34	Editorial Ciencias Médicas	10	0.27%
35	Georg Thieme Verlag KG	10	0.27%
36	German Medical Science GMS Publishing House	10	0.27%
37	Shahid Sadoughi University of Medical Sciences	10	0.27%
38	Mary Ann Liebert	9	0.24%
39	Tabriz University of Medical Sciences	9	0.24%
40	Universitas Airlangga	9	0.24%
41	Amaltea Medical Publishing House	8	0.22%
42	De Gruyter	8	0.22%
43	EMH Swiss Medical Publishers Ltd.	8	0.22%
44	KARE Publishing	8	0.22%
45	Ubiquity Press	8	0.22%
46	Future Medicine Ltd	7	0.19%
47	Hamadan University of Medical Sciences	7	0.19%
48	Health and Medical Publishing Group	7	0.19%
49	Kerman University of Medical Sciences	7	0.19%

50	Thieme Medical Publishers, Inc.	7	0.19%
51	Universidade de São Paulo	7	0.19%
52	Escola Bahiana de Medicina e Saúde Pública	6	0.16%
53	Iran University of Medical Sciences	6	0.16%
54	Mazandaran University of Medical Sciences	6	0.16%
55	Radcliffe Medical Media	6	0.16%
56	Universitas Padjadjaran	6	0.16%
57	AboutScience Srl	5	0.13%
58	Atlantis Press	5	0.13%
59	Babol University of Medical Sciences	5	0.13%
60	Bioscientifica	5	0.13%
61	EDP Sciences	5	0.13%
62	Elsevier España	5	0.13%
63	Guilan University of Medical Sciences	5	0.13%
64	Hindawi-Wiley	5	0.13%
65	NIHR Journals Library	5	0.13%
66	Negah Institute for Scientific Communication	5	0.13%
67	Publishing House Zaslavsky	5	0.13%
68	Universidad Nacional de Colombia	5	0.13%
69	AVES	4	0.11%
70	Badan Penelitian dan Pengembangan Kesehatan	4	0.11%
71	ECIMED	4	0.11%

72	European Publishing	4	0.11%
73	Exeley Inc.	4	0.11%
74	F1000 Research Ltd	4	0.11%
75	Galenos Publishing House	4	0.11%
76	Islamic Azad University	4	0.11%
77	Ivyspring International Publisher	4	0.11%
78	Master's Program in Public Health, Universitas Sebelas Maret	4	0.11%
79	Medical Communications Sp. z o.o.	4	0.11%
80	Pensoft Publishers	4	0.11%
81	Public Library of Science (PLOS)	4	0.11%
82	Shahrekord University of Medical Sciences	4	0.11%
83	The British Editorial Society of Bone & Joint Surgery	4	0.11%
84	Turkiye Klinikleri	4	0.11%
85	Ukrmedknyha Publishing House	4	0.11%
86	Universidad de Antioquia	4	0.11%
87	Universidade Estadual Paulista	4	0.11%
88	Universitas Gadjah Mada	4	0.11%
89	Universitas Indonesia	4	0.11%
90	Wolters Kluwer Health	4	0.11%
91	AIMS Press	3	0.08%
92	Afarand Scholarly Publishing Institute	3	0.08%
93	Centro Nacional de Información de Ciencias Médicas. Editorial de Ciencias	3	0.08%

Médicas (ECIMED)			
94	Emerald Publishing	3	0.08%
95	European Respiratory Society	3	0.08%
96	Galenos Yayincilik	3	0.08%
97	Golestan University of Medical Sciences	3	0.08%
98	IMA-PRESS LLC	3	0.08%
99	IMR (Innovative Medical Research) Press Limited	3	0.08%
100	IRBIS LLC	3	0.08%