Brain and Spine 3 (2023) 101720

Contents lists available at ScienceDirect

Brain and Spine

journal homepage: www.journals.elsevier.com/brain-and-spine

The current state of global contribution to open access publishing in neurosurgery: A bibliometric analysis

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ARTICLE INFO

Handling Editor: W Peul

Keywords:
Open-access
Global neurosurgery
Publication disparity
Neurosurgery literature

1. Introduction

Open access (OA) publishing refers to the practice of making scholarly research available online, free of charge, to anyone, anywhere. OA, therefore, provides information to researchers in developing countries who may not have the resources to pay for access to academic journals - promoting the dissemination of knowledge and facilitating collaboration among researchers. This is in contrast to the traditional model of publishing, in which researchers or institutions must pay to access the articles in academic journals. A key advantage to OA publishing is increasing visibility and availability, allowing for potentially more citation opportunities as well as quality assurance, since the article can be accessed and critically evaluated by a larger audience, which may also bring more transparency to research.

Unfortunately, there is one exception to the gratuity of OA: aspiring authors. In most cases, publishing OA articles require significant expenses in article processing charges (APCs). While it may represent a triviality to major institutions, it is a major expense to smaller hospitals in low- and middle-income countries (LMICs), to the point that publishing in this model may not be possible at all in these scenarios, especially in neurosurgery. While the literature is lacking in regards to neurosurgical research funding (and lack thereof) in LMICs, the amount of neurosurgical randomized control trials (RCT) may serve as a proxy for a better understanding of the monetary disparities between LMICs and high-income countries (HIC). It has been previously shown that most neurosurgical RCT occurs in HIC, which not only highlights the disparity in funding, but also an overarching difference in neurosurgical research output between HIC and LMICs (Griswold et al., 2020). The overall lack of funding may serve as a significant limitation to conducting research and overcoming publication fees in OAjournals, which have a median fee of about $3,300 for both OAand hybrid-style neurosurgical journals (Vacek and Kaliaperumal, 2022). Additionally, the neurosurgical capacity in LMICs is severely limited, pointing specifically to the lack of infrastructure, training, and funding in these countries (Fuller et al., 2015). These factors may place significant burdens on researchers from LMICs to overcome barriers to conduct research, publish, and even access scholarly articles.

Previous studies have highlighted this inequity in terms of

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https://doi.org/10.1016/j.bas.2023.101720
Received 31 January 2023; Accepted 2 February 2023
Available online 3 February 2023

publication output, with HIC contributing to the majority of neurosurgical literature (Paradie et al., 2022). To better understand the extent of disparity that occurs in contribution to the neurosurgical literature, examining the extent of OA publications, which predispose to increased readership, is warranted. Our aim is to review the OA journals within neurosurgery and evaluate the respective academic contributions of each country, with special consideration to the country's economy and region.

2. Methods

2.1. Source of data

The Directory of Open Access Journals (DOAJ) was used to query all neurosurgery journals that are completely OA. The DOAJ defines OAas instances where the copyright holder of the research work grants an OAlicense that is Creative Commons or equivalent without an embargo period. A global governing board oversees all decisions regarding journal compliance with OA publishing, with input and volunteers from every continent. The following terms were used to find journals: neurosurgery, neurological surgery, brain, head, cranial, spine, tumor, vascular, and stroke. The resulting journals were reviewed in PubMed for publishing neurosurgery articles. All publications with publication dates from January 1, 2018, to December 30, 2022, were collected. Journals not indexed in PubMed and those with less than 50 PubMed publications were excluded. Editorials, letters, responses, commentaries, opinions, and viewpoints were also excluded from the final analysis. To make publication volume relative to neurosurgical case volume and the number of neurosurgeons in each region, the recent paper by Dewan et al. was used as a source of data (Dewan et al., 2018). The following rations were utilized: neurosurgical cases: publication volume as well as neurosurgeons: publication volume.

2.2. Data acquisition

The National Center for Biotechnology Information Entrez database - a public, readily accessible program - was used to acquire publication information. Information was obtained from a single source: PubMed. Authors and their affiliations were determined based on structured abstract fields provided by PubMed. The publishing country as defined by the origin of the last author, H-index, impact factor, Scientific Journal Ranking (SJR), article processing fees, and PubMed results were collected for each journal. Article processing fees were determined using DOAJ and were collected on December 1, 2022. Data aggregation, analyses, and plots were performed using R, version 4.0.1 (R Foundation for Statistical Computing, Vienna, Austria). The income level for the 2021 fiscal year was determined using publicly-available data from the World Bank (2021). Using the World Bank Atlas method for gross national income per capita for official 2021 numbers, $1,085 or less is a low-income economy; between $1,086 and $4,255 is a lower middle-income economy, between $4,256 and $13,205 is an upper-middle-income economy, and $13,205 or more is a high-income economy. World Health Organization regions were used to designate a geographical location.

3. Results

Using the DOAJ, a total of 19 journals were included in the data extraction in PubMed. One journal was excluded due to having less than 50 publications, leaving the final bibliometric analysis for 18 journals. Table 1 demonstrates the included journal characteristics From the 18 journals, 5953 articles were initially identified, of which 258 (4.3%) articles were excluded due to article type. After screening, 5695 articles were included in the final analysis, representing a total of 76 countries that have been published in neurosurgery OA journals. Author affiliation was lacking in 44 articles.

The top three countries based on publication volume, the United States (n = 1567, 27.5%), Japan (n = 1041, 18.3%), and China (n = 622, 10.9%) made up 56.7% of the total OA contributions (Fig. 1). The full list of countries and their respective contributions and characteristics can be found in Table 2.

A total of 5 countries from low-income countries constituted <0.01%

Table 1
Open Access Journal Characteristics. SJR: Scientific Journal Ranking; APC: article processing charges; LMIC: low- and middle-income countries; NA: Not applicable.

Journal	H Index	Impact Factor	SJR	Total PubMed Results	Country	APC	Policy for discounts for LMIC	Discount Policy
Interdisciplinary Neurosurgery: Advanced Techniques and Case Management	11	0.49	0.182	46	Netherlands	$900	Yes	Research4life criteria
Stroke Research and Treatment	37	1.77	1.337	78	Egypt	$925	Yes	Research4life criteria
Journal of Neurological Surgery Reports	5	NA	0.193 (2017)	81	United States	$2,300	Yes	Research4life criteria
World Neurosurgery: X	7	2.62	0.885	85	United States	$1,950	Yes	Research4life criteria
Cerebrovascular Diseases Extra	17	2.05	0.715	98	Switzerland	$1,350	Yes	Research4life criteria
Brain and Spine	NA	NA	NA	125	Netherlands	$1,780	Yes	Research4life criteria
Neurointervention	NA	NA	NA	156	South Korea	None	Not applicable	Not applicable
North American Spine Society Journal	NA	NA	NA	171	United States	$2,100	Yes	Research4life criteria
Brain Circulation	19 (2021)	2.6 (2021)	NA	194	India	None	Not applicable	Not applicable
Chinese Neurosurgical Journal	8	1.35	0.273	202	China	None	Not applicable	Not applicable
Journal of Stroke	39	5.18	2.051	244	South Korea	None	Not applicable	Not applicable
Stroke and Vascular Neurology	27	7.8	1.801	329	United Kingdom	$1,800	Yes	BMJ Individual Agreement
Spine Surgery and Related Research	11	1.5	0.552	369	Japan	None	Not applicable	Not applicable
Neurologia Medico-Chirurgica	54	2.1	0.693	372	Japan	$100	Yes	Research4life group A
Neurospine	17	2.38	1.107	557	South Korea	None	Not applicable	Not applicable
Asian Spine Journal	34	2.54	0.999	657	South Korea	None	Not applicable	Not applicable
Brain Stimulation	89	4.92	2.352	1179	USA	$3,310	Yes	Research4life criteria
Global Spine Journal	33	2.2	1.168	1324	United States	$2,100	Yes	Research4life criteria

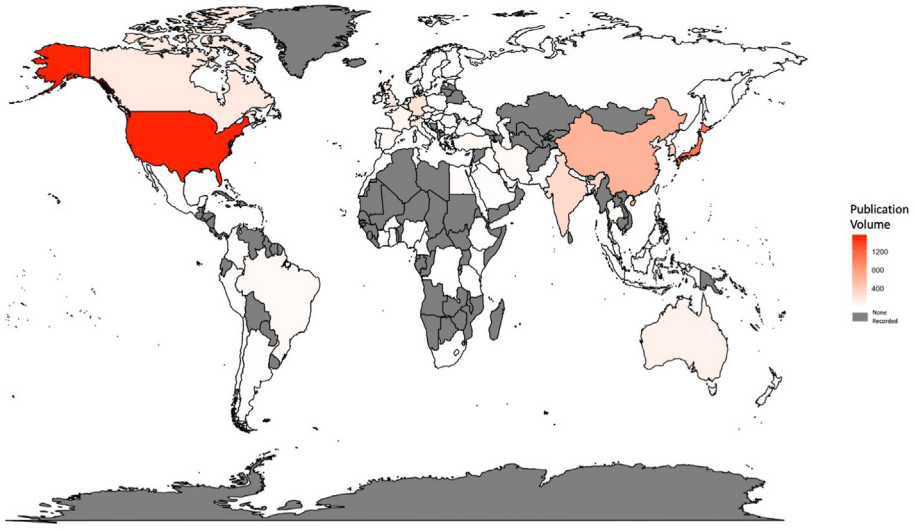

Fig. 1. Geographic distribution of publication volume for open access journals.

(n = 9) of the total publication volume. A total of 17 countries from lower-middle income constituted 7.3% (n = 417) of the total publication volume, of which India alone accounted for the vast majority (5.25%) (n = 119). Upper-middle-income countries with representation from 16 different countries constituted 14.4% (n = 822) of the total publication volume. A total of 38 countries from HIC constituted 78.1% (n = 4447) of the total publication volume.

From the African WHO Region, 10 countries participated for a total cumulative volume of 0.3% (n = 19). From the Americas WHO Region, 9 countries participated for a total cumulative volume of 31.9% (n = 1818). From the Eastern Mediterranean WHO Region, 11 countries participated for a total cumulative volume of 1.9% (n = 111). From the European WHO Region, 31 countries participated for a total cumulative volume of 19.4% (n = 1104). From the South-East Asian WHO region, 6 countries participated for a total cumulative volume of 6.2% (n = 352). Lastly, the 9 countries from the Western Pacific WHO region constituted 40.2% (n = 2291) of the total publication volume.

Of the 5695 articles included, 554 (9.7%) contained review articles. In an analysis of article process fees, 11 of 18 journals (61.1%) reported any type of article processing fee to the author. Of these journals, all had policy discounts for authors from LMICs. The most common discount policy involved the use of Research4life criteria (n = 9, 81.8%). The mean article processing fee across the 11 journals was USD$1,692 (range = $100 - $3310). Article processing fees were used to publish 3421 (60.1%) articles in 11 unique journals. Of the 3434 articles that faced article processing fees, low-income countries accounted for 0.2% (n = 8) of the publication volume, lower-middle-income countries accounted for 4.40% (n = 151) of the publication volume, upper-middle-income countries accounted for 14.4% (n = 492), and HIC accounted for 81.0% (n = 2770). There was a broad divergence in publication volume by WHO region: Africa (0.6%, n = 10), Americas (38.8%, n = 1329), Eastern-Mediterranean (1.5%, n = 53), Europe (23.9%, n = 818), South-East Asia (3.2%, n = 111), and Western Pacific Region (31.9%, n = 1091). Table 3 demonstrates the ratios for neurosurgical cases: publication volume and neurosurgeons: publication volume with greater ratios demonstrating a greater disparity between neurosurgery metrics and publication volume. Notably, the greatest neurosurgical cases: publication volume ratio was 198639.20 in the African WHO region and the lowest was 996.08 in the Americas WHO region. Overall, the LMICs ratio was 25231.26 while the HIC ratio was 558.24.

4. Discussion

Collectively, LMICs make up less than 8% of the total OA publications in the last five years in the 18 dedicated OA journals. There exist major regional differences in publication volume as well between WHO regions. We have shown the obvious disparities in contribution to OA publishing in neurosurgery, potentially affecting the clinical practice and the way in which scholarly work is disseminated internationally.

4.1. Barriers to publishing

Significant barriers in neurosurgical care and research exist in LMICs, including lack of equipment, trained professionals, and availability of services at reasonable cost and distance (Weiss et al., 2019). These barriers not only limit adequate care but infiltrate into the realm of academia, as neurosurgical publications in LMICs are severely limited in comparison to HIC (Griswold et al., 2020; Bibbins-Domingo et al., 2022). There is a wealth of information found in research produced by LMICs that is under-documented or hidden behind paywalls. One study determined that the most common neurosurgical diagnoses in these countries were traumatic brain injury and hydrocephalus (Bibbins-Domingo et al., 2022). Understanding how these countries manage these patients with few resources can prove extremely beneficial to global healthcare (Richards and Tumwine, 2004). There has been a recent trend of seeing an increased number of publications from LMICs from 2015 to 2020 in both OA and restricted access journals. However, these publications only contribute to roughly 5% of the total number of published neurosurgical articles worldwide (Cannizzaro et al., 2022), suggesting that there is still much work to be done to increase the globalization of neurosurgical research.

LMICs face repeated hurdles to publishing, trapping researchers in these countries into a cyclical pattern of limitations and inaccessibility. Multiple barriers limit the overall output of studies in LMICs. The researchers that overcome these initial barriers are met with a new financial barrier in OApublishing due to overwhelming fees and must resort to traditional journals with restricted access. These publications are then inaccessible to these same LMIC researchers and colleagues from the region, due to a lack of institutional access and journal subscriptions, leading to limited academic information sharing in the region. These barriers to academic publishing can have particularly insidious effects

Table 2
Countries, characteristics, and their respective contribution to publication volume. AMR: America; WPR: Western Pacific; SEAR: South-East Asia; EUR: Europe; AFR: Africa; EMR: Eastern mediterranean.

Country	Count	% of Total Publication Volume	Count in Article Processing Fee Journals	Income Status	WHO Region
USA	1567	27.5	1139.0	High Income	AMR
Japan	1041	18.3	505.0	High Income	WPR
China	622	10.9	394.0	Upper Middle Income	WPR
South Korea	386	6.8	53.0	High Income	WPR
India	298	5.2	84.0	Lower-Middle Income	SEAR
Germany	224	3.9	179.0	High Income	EUR
Canada	175	3.1	135.0	High Income	AMR
UK	154	2.7	135.0	High Income	EUR
Italy	109	1.9	84.0	High Income	EUR
Australia	107	1.9	83.0	High Income	WPR
Netherlands	92	1.6	75.0	High Income	EUR
France	81	1.4	49.0	High Income	EUR
Switzerland	79	1.4	55.0	High Income	EUR
Singapore	53	0.9	23.0	High Income	WPR
Spain	51	0.9	32.0	High Income	EUR
Turkey	51	0.9	16.0	Upper Middle Income	EUR
Taiwan	46	0.8	17.0	High Income	WPR
Iran	42	0.7	19.0	Lower-Middle Income	EMR
Brazil	39	0.7	31.0	Upper Middle Income	AMR
Belgium	38	0.7	36.0	High Income	EUR
Denmark	35	0.6	28.0	High Income	EUR
Thailand	34	0.6	13.0	Upper Middle Income	SEAR
Israel	30	0.5	18.0	High Income	EUR
Egypt	24	0.4	14.0	Lower-Middle Income	EMR
Sweden	24	0.4	14.0	High Income	EUR
Austria	20	0.4	15.0	High Income	EUR
Malaysia	20	0.4	5.0	Upper Middle Income	WPR
Finland	16	0.3	11.0	High Income	EUR
Greece	16	0.3	5.0	High Income	EUR
Saudi Arabia	16	0.3	8.0	High Income	EMR
Czech Republic	15	0.3	13.0	High Income	EUR
Norway	14	0.2	13.0	High Income	EUR
Indonesia	13	0.2	10.0	Lower-Middle Income	SEAR
Pakistan	13	0.2	3.0	Lower-Middle Income	EMR
Portugal	13	0.2	12.0	High Income	EUR
Russia	13	0.2	5.0	Upper Middle Income	EUR
New Zealand	12	0.2	9.0	High Income	WPR
Mexico	11	0.2	4.0	Upper Middle Income	AMR
Ireland	10	0.2	9.0	High Income	EUR
Argentina	9	0.2	8.0	Upper Middle Income	AMR
Colombia	9	0.2	6.0	Upper Middle Income	AMR
Chile	6	0.1	5.0	High Income	AMR
Ethiopia	5	0.1	5.0	Low Income	AFR
Ghana	4	0.1	4.0	Lower-Middle Income	AFR
Jordan	4	0.1	4.0	Upper Middle Income	EMR
Nepal	4	0.1	3.0	Lower-Middle Income	SEAR
Philippines	4	0.1	2.0	Lower-Middle Income	WPR
Iraq	3	0.1	0	Upper Middle Income	EMR
Poland	3	0.1	3.0	High Income	EUR
Tunisia	3	0.1	1.0	Lower-Middle Income	EMR
Bangladesh	2	0.0	1.0	Lower-Middle Income	SEAR
Bulgaria	2	0.0	1.0	Upper Middle Income	EUR
Croatia	2	0.0	1.0	High Income	EUR
Cyprus	2	0.0	1.0	High Income	EUR
Estonia	2	0.0	2.0	High Income	EUR
Lebanon	2	0.0	2.0	Lower-Middle Income	EMR
Nigeria	2	0.0	2.0	Lower-Middle Income	AFR
Romania	2	0.0	1.0	High Income	EUR
Slovakia	2	0.0	2.0		EUR

(*continued on next page*)

Table 2 (*continued*)

Country	Count	% of Total Publication Volume	Count in Article Processing Fee Journals	Income Status	WHO Region
				Upper Middle Income	
Tanzania	2	0.0	2.0	Lower-Middle Income	AFR
United Arab Emirates	2	0.0	1.0	High Income	EMR
Burkina Faso	1	0.0	1.0	Low Income	AFR
Cameroon	1	0.0	1.0	Lower-Middle Income	AFR
Democratic Republic of the Congo	1	0.0	1.0	Low Income	AFR
Hungary	1	0.0	1.0	High Income	EUR
Ivory Coast	1	0.0	1.0	Low Income	AFR
Kenya	1	0.0	1.0	Lower-Middle Income	AFR
Morocco	1	0.0	1.0	Lower-Middle Income	EMR
North Korea	1	0.0	0	Low Income	SEAR
Peru	1	0.0	1.0	Upper Middle Income	AMR
Qatar	1	0.0	0	High Income	EMR
Serbia	1	0.0	1.0	Upper Middle Income	EUR
Slovenia	1	0.0	0	High Income	EUR
South Africa	1	0.0	1.0	Upper Middle Income	AFR
Trinidad	1	0.0	0	High Income	AMR
Ukraine	1	0.0	1.0	Lower-Middle Income	EUR

over time. It has been noted that lack of attention to diseases primarily concentrated in LMICs receives significantly less research attention, such that diseases more prevalent in HIC generate almost ten-fold more research attention than those in lower-income countries (Yegros-Yegros et al., 2020).

The time constraint for LMIC researchers, particularly in areas with a low neurosurgical workforce (Mukhopadhyay et al., 2019), may likely play a large role in restricting access to publishing. Along with this, many LMIC researchers lack experience in publishing peer-review research as well as formal training in research project management (Busse and August 2020). As a result, there has been a growing effort to promote mentorship, onsite training, and peer-review services through non-profit initiatives like Pre-Publication Support Services (Busse and August 2020). These initiatives, however, are frequently of a restricted scale and might not be adequate to solve the more significant issues that these nations are facing.

An increase in funding for OApublication is one possible solution to the overarching issue of access to academic publishing in LMICs, which stems from systemic inequities between LMICs and HICs. OAfee waivers for LMICs have been seen in various sub-specialty journals (Gardner et al., 2021). Some neurosurgical journals, like *Interdiscipinary Neurosrugery* and *The BMJ*, also offer the option of waiving APC for specific countries. However, a large portion of OA neurosurgical journals do not offer these discounts (Fuller et al., 2015). Although the rate of LMICs OA publishing has increased over time (Iyandemye and Thomas, 2019), the overall contribution compared to HICs is still disparately low. This may point to other factors, like a lack of neurosurgeon density, as one primary driver in the limited neurosurgical research output from LMICs, as well as a high percentage of rejections due to a lack of formal training in peer-reviewed publishing.

For OA journals that do offer discounts, some waive APCs for institutions with which they have a standing contract with, such as universities in particular countries of major research groups (i.e. National Institute of Health). This invariably biases HICs as contracts that are financially incentivized could be made more often with institutions in countries that are able to afford the premium.

4.2. Barriers to access

Along with the difficulty in publishing, LMICs also face difficulties in accessing scholarly journals, due to the high cost of academic journal and database subscriptions, as well as the limited infrastructure that supports access to scholarly work (Muula, 2008). An inability to access the most recent academic articles and research may make it challenging for students and researchers to stay current with the most recent advancements in their disciplines (Bibbins-Domingo et al., 2022). Their capacity to develop their studies and professions, as well as their ability to make contributions to the academic community, may be hampered as a result. Recent efforts, impelled by the Covid-19 pandemic, have called for more readily accessible and wider-scale dissemination of research studies as well as data-sharing (Flanagin et al., 2022), but there may still be a barrier to access to LMICs. OA journals do contribute to solving this issue, allowing more access to research, given that there are means to do so (e.g.: internet connection).

Impaired access to academic publications in LMICs is being addressed through a number of initiatives. Some publishers provide citizens and organizations in certain nations with subsidized or free access to their publications. Programs like the Research4Life program give eligible institutions in low- and middle-income nations access to scholarly journals for free or at a reduced cost (Research4Life, 2023). Countries are able to

Table 3
WHO Region Analysis of Neurosurgeon and Publication Volume. HIC: high-income countries; LMIC: low-middle income countries; AMR: America; WPR: Western Pacific; SEAR: South-East Asia; EUR: Europe; AFR: Africa; EMR: Eastern Mediterranean.

WHO Region	Publication Volume	Estimated No. Neurosurgical Cases[a]	Operations: Publications Ratio	No. Neurosurgeons[a]	Neurosurgeons: Publications Ratio
AFR	10	1986392	198639.20	488	48.80
AMR	1818	1810868	996.08	9512	5.23
EMR	111	1057015	9522.66	2073	18.68
EUR	1104	1756891	1591.39	10719	9.71
SEAR	352	3504783	9956.77	4409	12.53
WPR	2291	3670873	1602.30	22114	9.65
HIC	4447	2482475	558.24	–	–
LMIC	426	10748517	25231.26	–	–

[a] Data provided by Dewan et al., 2018)

qualify based on a number of country-related financial metrics. Countries in their 'Group A' list, which are generally low-income countries, receive free access, while those in the 'Group B' list receive fee-based access. More recent initiatives, like those taken by JAMA (Bibbins-Domingo et al., 2022), have given researchers the option to submit accepted manuscripts to a public online repository, in an effort to eliminate the knowledge barrier with countries that cannot access certain journals. Still, there is room for improvement in multiple domains, such as equitable access to publishing and an increase in funding for certain scientific domains.

Poor access to academic publishing is a significant problem for LMICs. It will be crucial to create methods that can offer trustworthy and affordable access to academic publications, like OA publishing, in order to address this issue. By expanding access to academic publications, we can ensure that students, researchers, and institutions in these nations have the resources they need to progress their education and careers, as well as to contribute to the global academic community.

4.2.1. Limitations

The present analysis is not without limitations. By design, we included articles that were completely OA, as defined by the DOAJ. While the search engine and methodology rely completely on indexing within PubMed, the vast majority of neurosurgery OA journals use this database to archive articles. It remains a possibility that certain articles are published by journals indexed in PubMed but do not result in being indexed in PubMed individually. Due to the methodology of this search strategy, journals that were not indexed within the DOAJ were excluded, potentially excluding journals that are OA but not indexed. We believe that the DOAJ is an appropriate standard to use and has adequate international coverage and delegation from all continents. Another limitation is that the volume of publications is, in part, the result of having more neurosurgical centers and therefore more people practicing neurosurgery based on the total population. Given the analysis by region as well as by income status, we hope to show adequate deduction as to trends in publication behavior. The exact institutions with which OA journals have contracts with is as well as distribution of OA downloads would be interesting points of analysis, but we were unable to analyze this due to data availability and should be a goal of future research. Cross-country collaboration is possible and the present study only gave consideration to the senior author's residence, potentially leaving some country contribution left unrepresented in the final analysis. Lastly, articles being contributed in non-DOAJ journals or non-English native journals were not included in the following analysis but could be a major destination for LMIC research and should be an area of future research.

5. Conclusion

OA publishing has greatly improved access to publications, but the ability to publish in OA journals is still troublesome. There is a stark difference in the amount of OA publications in neurosurgery from HICs when compared to LMICs, owing to both barriers to publishing and barriers to access to adequate resources to foster these articles. Since LMICs have their own challenges, we believe that allowing for more research from these areas to be published would vastly improve the quality of LMICs healthcare services as well as of professionals. Aside from bringing this issue to the surface with further research, we believe that solutions to this should be sought by journals by facilitating access and by researchers and institutions with more international collaborations.

Declaration of competing interest

The authors declare no conflicts of interest in the preparation of this manuscript.

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