International disparities in open access practices in the Earth Sciences

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Abstract.

Background. Open Access (OA) describes the free, unrestricted access to and re-use of research articles. Recently, a new wave of interest, debate, and practice surrounding OA publishing has emerged.

Objectives. The paper presented here focuses on international disparities in OA publication practices of the Earth Science community. We aim to provide an overview of actual publication practices and comparison between several countries with the intention of stimulating further debate and raising awareness to aid the decision-making processes for the further development of OA practices in the Earth Sciences.

Methods. Number of OA articles, proportion of OA articles by countries and journals' selection was performed using the Scopus and Web of Science indexing databases.

Results. In 2018, only between 24 and 31% of total articles were available as OA. The ten top journals for Earth Sciences that publish OA articles are mostly fully OA (6) or hybrid journals (4). Fully OA journals are mostly published by emerging publishers and have a large range of Article Processing Charges (APCs) from less than $US 1000 up to $US 3000.

Conclusions. The rise in OA publishing has potential impacts for the profiles of researchers and tends to devolve publication costs from organizations to individuals. Until the Earth Sciences community makes the decision to move away from journal-based evaluation criteria, it is likely that such high costs will continue to impose financial inequities upon this research community, especially for researchers from least developed countries. However,

Earth Scientists could more widely choose legal self-archiving as an equitable and sustainable way to disseminate their research.

Keywords. geoscience; open science; preprint; article processing charge; repository; predatory.

Introduction

Every paper has its own unique audience. Some papers go to journals like *Science* or *Nature*, while others go to the *South African Journal of Science* or the *Journal of Asian Earth Science*, and there are usually valid reasons for choosing either. Some papers may be discipline-specific or multi-disciplinary, while others have a local focus or global significance. Some papers are purely theoretical while others are more applied and will have immediate tangible benefits for society, culture, and/or the economy. Others might have little or no practical use whatsoever at present but nevertheless remain valuable contributions in our constant quest for knowledge. Scholarly journals are the primary vehicle for communicating research to other researchers and the wider public, and have traditionally been run by various societies and associations[1]. Some journals have remained independently-run by scholarly communities, while some commercial publication houses have slowly enveloped most journals[2]. Thus, where authors consider submitting a research paper is dependent on a number of factors: indexing status, readership, type of journal (scholarly vs popular magazine), Journal Impact Factor (JIF), language, type of article (regular research article versus review article versus commentary), average peer review speed and reputation, Article Processing Charges (APCs) and/or additional publication charges. The list goes on.

The digital age is also forcing scholarly publishing to undergo a major transformation. A decline in printed paper editions, the high costs of journal subscriptions, and increasing publication costs are all spurring scientists to look for alternative outlets to traditional scientific publishing[3-4]. In addition, according to the International Association of Scientific,

Technical and Medical Publishers[5], two-thirds of the scholarly literature produced in 2016 remains mostly inaccessible to the public because the work is hidden behind prohibitively expensive subscription paywalls. This is driving an ever-increasing move to Open Access (OA), which, while generally slow, marks a significant shift in major publishers' financial models, within a scientific, technical and medical information publishing market that generated US $25.7 billion in 2017. Consequently, this has opened greater diversity in publishing routes, and highlighted major issues around publishing ethics, such as copyright infringement and the [in]appropriate expenditure of public funds. Ensuring that researchers as authors and their institutions do not have to pay even more to read and publish papers than they currently do has become a critically important part of the OA transition[6]. Academic publishing via OA aims to make scientific content more accessible online and has been around in various forms for almost three decades. However, OA too often gets conflated with just one mechanism, namely the author-facing business model of APCs, whereby authors pay an APC to cover the cost of publishing[7]; disadvantaging the already disadvantaged academics. Indeed, Pourret et al.[7] highlight that there are different ways of achieving OA which are identified as Gold, Bronze, Green or Diamond. Green and Diamond OA have no Article Processing Charge (*i.e.* publication fee; APC). Green OA corresponds to the self-archiving on a personal website, or on an archive of a near-final and peer-reviewed version of their work. Use of trusted archives is usually preferable. Diamond OA denotes the free supply of content on a journal website (*i.e.* without any APCs). Gold OA involves APCs to be paid for immediate publishing access. Bronze OA refers to articles made free-to-read on the

publisher website, but without any explicit open license, which potentially inhibits their future re-use. This issue is critically important as the APCs typically associated with OA publishing may disadvantage researchers from developing countries who do not have the funds to pay these publication fees[8]. Retraction Watch (https://retractionwatch.com/2020/06/16/failure-fails-as-publisher-privileges-the-privileged/) recently highlights that some publishers (e.g. MDPI), by favoring article submissions of researchers from developed countries, privileges the privileged even more. This brief history is important when one considers that the ultimate aim of publishing research is to disseminate information and describe advances in science which benefit society, especially now in the increasingly important context of the United Nations Sustainable Development Goals[9].

In this contribution, we briefly discuss key differences in publication strategies between Earth scientists from around the world. We discuss differences in our experiences and understanding of financial pressures (OA vs paywall), quality (predatory journals), geographical extent (regional vs international).

Material and methods

This article combines raw datasets from the indexing databases of Scopus and Web of Science (WoS). Using both databases, the following information was extracted (Table 1): total articles, and OA articles for research areas “Geochemistry and Geophysics” and “Geology” in Web of Science categories and “Earth and Planetary Sciences” in Scopus categories for 2018. Information was collated from the six countries in which the authors

work, namely China, England, France, Indonesia, South Africa and the United States of America (Table 1). Country is based on the affiliation of authors and the same article can count several times when international collaboration occurs. We also have selected the ten top journals (by number of articles according to SCOPUS category “Earth and Planetary Sciences”) publishing OA articles for which we extracted the number of OA articles, the proportion of OA articles, the status (fully OA or hybrid), the APC, the JIF from 2019 and the name of the publisher (see Table 2).

Results

The typical scholarly publication routes are illustrated in Figure 1. Gold OA is now mostly funded by institutions through “Read and Publish” agreements or direct support from research funding agencies, and in some cases through researchers themselves. The non-OA and green self-archiving routes are typically only funded by institutions and funding agencies (*i.e.* because there are no author-facing charges). If a researcher happens to be within an institution that can afford to pay both APC and journal subscriptions, this does not seem to be a big issue; the cost is supported externally, and thus there is no incentive for authors to publish in less-expensive platforms which might be seen as having a lower value. However, for other institutions (with lower budgets) and for their individuals, cost certainly remains an obstacle. While many authors seem to equate OA with a specific form of business model (APC-driven gold), this is clearly erroneous and a myth that should be dispelled.

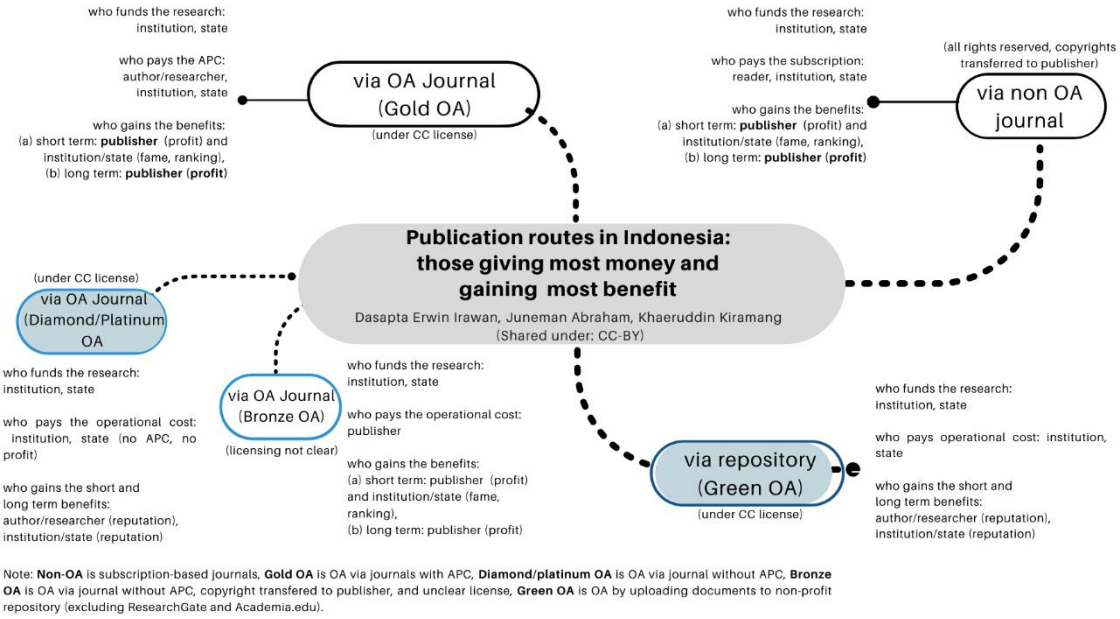

Figure 1: The academic publication route: a schematic representation of different OA decision steps highlighting financial burden and benefit/reward for different stakeholders (adapted from Irawan et al.[10]).

From the distribution of articles and proportion of OA articles published in 2018 that have been indexed in the WoS categories “Geochemistry and Geophysics” and “Geology” and the Scopus category “Earth and Planetary Sciences” and stratified by country (Table 1), it can be seen that only between 24 and 31% of total articles are available as OA. Between 46 and 54% are published via OA in England/United Kingdom (UK), whereas some other countries seem to contribute a much lesser proportion (*i.e.* France 29-42%, Indonesia 23-53%, South

Africa 19-37% and the United States of America (USA) 25-46%) and eventually China has the lowest proportion (i.e. 18-20%). It must be noted that the number of OA articles is higher in Scopus when compared to WoS (33,135 vs 3,271 and 9,369) and the proportion of OA is higher (31% vs 24% and 31%).

A closer look at the top ten journals that publish OA articles in Earth Sciences (Table 2) reveals that six are fully OA and four are hybrid journals. Fully OA journals are mostly published by emerging publishers (e.g. MDPI[11], Hindawi) or long time OA publishers (Copernicus/EGU) and have a large range of APCs from less than $US 1000 up to 2000, and JIF from 1.3 to 5.4 (one of the journals is not indexed). Hybrid journals are published by older publishers (e.g., EDP Sciences, Wiley/AGU, Oxford/Royal Astronomical Society, American Meteorological Society) and have higher APCs from $US 1000 up to 3000, and higher JIF ranging from 4.6 to 6.2.

Table 1: Number of articles published in 2018, of OA articles and proportion of OA articles indexed in WoS categories “Geochemistry and Geophysics” and “Geology”, and Scopus category “Earth and Planetary Sciences” alphabetically ordered by countries (data accessed on 02/26/2020). (to be continued)

	“Geochemistry and Geophysics” WoS category			“Geology” WoS category		
	Total number of articles	Number of OA articles	Proportion of OA articles (%)	Total number of articles	Number of OA articles	Proportion of OA articles (%)
Total	13,436	3,271	24	30,189	9,369	31
China	3,492	651	19	7,277	1,295	18
England	1,063	574	54	2,545	1,618	64
France	1,145	333	29	2,085	851	41
Indonesia	26	6	23	173	91	53
South Africa	134	26	19	415	81	20
USA	3,569	902	25	6,761	2,523	37

Table 1: Number of articles published in 2018, of OA articles and proportion of OA articles indexed in WoS categories “Geochemistry and Geophysics” and “Geology”, and Scopus category “Earth and Planetary Sciences” alphabetically ordered by countries (data accessed on 02/26/2020). (continued)

	“Earth and Planetary Sciences” Scopus category		
	Total number of articles	Number of OA articles	Proportion of OA articles (%)
Total	106,241	33,135	31
China	30,877	6,321	20
England /UK	9,749	4,516	46
France	6,949	2,916	42
Indonesia	561	254	45
South Africa	1466	538	37
USA	25,108	11,486	46

Table 2: Top journals (by number of articles according to SCOPUS category "Earth and Planetary Sciences") publishing OA articles

	Number of OA articles	%OA	Status	APC	JIF 2019	Publisher
Remote Sensing	1,963	100%	Full-OA	2200 CHF	4.118	MDPI
Astronomy and Astrophysics	1,805	99%	Hybrid	3000 US$	6.209	EDP Sciences
Atmospheric Chemistry and Physics	941	100%	Full-OA	1000 US$	5.414	Copernicus/EGU
Geophysical Research Letters	700	48%	Hybrid	2500 US$	4.580	Wiley/AGU
Monthly Notices of the Royal Astronomical Society	573	17%	Hybrid	3035 US$	5.356	Oxford/Royal Astronomical Society
Minerals	556	100%	Full-OA	1800 CHF	2.380	MDPI
Shock and Vibration	504	100%	Full-OA	2200 US$	1.298	Hindawi
Geosciences	450	100%	Full-OA	1200 CHF	na	MDPI
Journal of Climate	417	77%	Hybrid	1100 US$	5.707	American Meteorological Society
Biogeosciences	416	100%	Full-OA	1000 US$	3.48	Copernicus/EGU

Discussion

Open Access policy

The majority of Earth Sciences knowledge production from China was formerly published in hybrid journals. This trend can be attributed to a historical national incentive for researchers to publish in top journals (*i.e.,* high JIF and first quartile) categorized by the Chinese Academy of Sciences (*i.e.*, those that publish the least reliable work)[12]. In many cases, one of the only options for Chinese authors was to publish their research in a "high impact" predominantly English hybrid journal without paying the APC and place their paper behind a paywall. However, this policy changed in early 2020. China has just published a national-level policy to ban the use of journal-based metrics as assessment criteria for academic promotion and recruitment, which should in future give priority to the innovation of one's work and significance of representative achievements in solving practical problems[13]. Further, publication in Chinese journals is being proposed as part of the prerequisites for application of top national awards. A move away from high JIF journals to Chinese journals could be a real game changer as Chinese researchers produce the bulk of articles[14]. This is seen as a responsible first step for research evaluation reform in China and encourages other nations to adopt similar policies. Specifically, the new policy tackles perverse incentives that drive the "publish or perish" culture which might be encouraging questionable research practices. Owing to the drive to address (local) practical problems in this new policy and the need to target a specific audience, more research will probably be published in Chinese national

journals (*e.g.*, *Acta Petrologica Sinica, Geology in China*), the majority of which have page charges and are fully OA by default and continue to feed the common misconception that OA equals author-facing charges. Indeed, there are toll-access journals (*i.e.* not OA) that have page charges and there are OA journals without any page charges or APCs.

Pourret et al.[4] highlight that publicly-funded research in the United Kingdom (UK) has to be made available through OA in order to abide by the UK Research and Innovation policy. UK research councils provide universities with a tranche of money specifically dedicated to cover costs of gold OA publishing through APCs. Each university then uses that pot of money how they see fit: some cover gold OA costs for publications by their researchers on a first come, first served basis, while others favor publications they believe will have a higher impact. Any publication not selected for gold OA (*e.g.*, because it was not deemed impactful enough, or because the money has run out) has to be deposited green OA at no charge to authors, and there is a general policy for self-archiving in order for works to be eligible for assessment in the UK's Research Excellence Framework. Some universities also have restrictions on publishing in hybrid journals, due to their lower-quality standards and relatively higher costs. Currently the Joint Information Systems Committee (JISC; https://www.jisc.ac.uk) is negotiating national-level agreements with commercial publishers. These contracts involve donating millions of pounds of public money each year to sustain the dysfunctional commercial publishing sector. They do this while simultaneously neglecting to invest in an open scholarly infrastructure, and thus while often termed "transformative agreements", it can be argued that a more accurate term could be "stagnation agreements". This situation is

being replicated by many countries around the world, as they try to realign themselves with recent changes implied by Plan S[15]. The movement around Plan S (https://www.coalition-s.org), a funder-led initiative launched in September 2018, aims to accelerate the full transition towards OA. These initiatives have opened up discussions about journals' and research communities' aptitude to correctly and sustainably shift towards a dominantly OA model[4]. Higher education leaders in many countries including South Africa are looking to move to a European model[16]. The major consequence of Plan S in the UK is an increase of OA publications with a shift from hybrid to fully OA[17].

Other countries such as Denmark and France (as most European countries) are having considerably more success by investing through libraries into green OA as part of their national policy[7]. This policy means that, to the largest possible extent, researchers and their institutes ensure that a peer-reviewed copy of a manuscript that is accepted for publication is uploaded to the appropriate institutional repositories whenever legally and technically possible[7]. In Denmark, there is a green OA policy which has existed since 2016. This policy means that, to the largest possible extent, researchers and their institutes ensure that a peer-reviewed copy of a manuscript accepted for publication is uploaded to the appropriate institutional repositories whenever legally and technically possible. As such, this does not constrain researchers in their choice of publishing channel, as virtually all journals allow this or even deposit articles automatically after an embargo period, often on behalf of authors in repositories. At the moment, approximately 45% of the Danish annual research production is being uploaded into the universities' repositories (https://www.oaindikator.dk/en/). This

overall proportion is comparable with 49% of the annual research publications in France in 2018 being available as OA (including 'green' OA, not considered in our evaluation; https://ministeresuprecherche.github.io/bso/). Furthermore, some libraries in Denmark have allocated specific funds for paying of APCs, albeit requiring that the corresponding manuscripts are made available through institutional repositories as well, in order to count as green OA in the sense of the national policy.

Indonesia recently became the world leader for publishing research via OA, thanks largely to efforts to index their journals in the Crossref registry[18]. However, this significant shift to OA scientific publishing has not yet changed the way the Indonesian government measures staff performance and research impact[19]. The newest Indonesia's regulation of staff promotion released in January 2020 still favours the metric-based measurement of research out by putting a maximum score of 40 to articles published in journals with higher JIFs than those in local journals (maximum score 25). Publishing in journals with high JIF or journals in quartile 1 in Scimago list is mandatory to be promoted to professor. Currently all big universities in Indonesia are actively offering APC payment and incentive for authors who are able to publish an article in so-called reputable journals. The way the Indonesian government allocates funding to higher education has been distorted as more money flowed to the end-point research and innovation, rather than constructing a good basis of research infrastructure. In the long run, this policy doesn't create resilience in the local academic/research ecosystem. A similar phenomena appears in other nations, such as India

which is an immediate example since it is planning to implement a one nation-one subscription plan[20].

In South Africa, there are currently no formal policies to publish OA. Although not linked directly, universities cover APCs, it has been noted[21]. Universities typically provide financial support to cover APCs but this monetary support is typically capped at less than US$ 900. There is no stipulation as to whether this monetary support must be used for the various types of OA or in hybrid journals, the only criterion is that the journal must be accredited by the South African Department of Higher Education, Science and Innovation. Unfortunately, some universities in South Africa pay faculty members' bonuses when articles are published which has resulted in some dubious publication practices[22].

In the USA, open access policies are mixed in the Earth sciences community. Gold OA is covered by some universities, typically those with sufficient resources, or where grants have specifically budgeted for it. Additionally, some institutions, in conjunction with their subscription plans, have agreements with publishing companies to cover discount open-access author publishing charges with society journals (such as AGU). These arrangements are viewed as beneficial to the publishers, the institutions and the societies by helping keep subscription prices down. However, as evidenced by recent ongoing negotiations (since 2019) between Elsevier and the University of California system, such arrangements can be a sticking point and has resulted in the University of California unsubscribing from *Elsevier*'s journals and calls for faculty to withdraw from editorial boards of journals published by *Elsevier*. The major US societies (*e.g.* AGU, Geochemical Society…) host journals with

hybrid open-access options as well as full open-access. Further, funding agencies such as the National Science Foundation (NSF) require principal investigators to deposit papers arising from work funded by NSF grants into a public access repository (*e.g.* https://par.nsf.gov/).

Global inequalities

The APC-dominated philosophy has created a complex system and hierarchy of financial privilege around OA publishing[17]. In this situation, those researchers who can afford to publish in OA journals, and in particular those which have a high JIF and charge high APCs are given an advantage over those who do not benefit from such financial security and are restricted in choice imposed by their inability to afford APCs. Given that it is now recognized that OA publishing tends to lead to increased 'impact' for researchers[23], the inherent bias of the current APC-based OA publishing perpetuates this through the "Matthew Effect" (*i.e.* the rich get richer and the poor get poorer). The switch from pay-to-read to pay-to-publish has left essentially the same people behind[8]. With some academics not having enough purchasing power (individually or through their institutions) for either option[24].

Virtually everyone who might benefit from access to research has limited access to papers kept behind paywalls. For many countries, Hedding[8] highlights that it is extremely expensive for university libraries and non-academics to pay to access published scientific content; a problem that is even greater for less-financially developed nations. OA may conceptually

address these negatives by increasing access for the reader, but it often simply shifts the financial burden to the researcher (Figure 1). Shifting towards OA creates inequalities between countries that have substantial financial resources and those that might have more difficulty to pay (often high) APCs. That some countries have allowed the scholarly publishing system to essentially become a public financing machine for this inequity is a paradoxical phenomenon, and indicates a horrendous mismanagement of relevant publishing funding streams, failure to understand even basic market principles, and the compromise of public interests to protect those of the commercial sector. However, Indonesia has more than 1571 OA journals and ranked second after the UK in the Directory of Open Access Journals database (DOAJ; https://doaj.org/). The majority (i.e. 70%) of these journals do not have APCs[25] and are funded by local universities and research institutions and published locally. Journals listed in the DOAJ mostly publish English-language articles but only represent one-sixth of the Indonesian journals listed in the Indonesian national GARUDA database (http://garuda.ristekdikti.go.id/). The GARUDA now indexes more than 1.1 million articles, published in more than 9600 Indonesian journals, maintained by more than 1600 publishers. Journals which charge a moderate APC are mostly the ones that have been indexed by indexing services (e.g., *Indonesian Journal on Geoscience*), and are considered to be of higher quality as a result. The regulation of Indonesia's higher education system gives a higher score to articles published in journals and conference proceedings listed in Scopus, of which only 47 Indonesian journals are currently listed. However, even indexing services such as Scopus have been infiltrated by predatory journals which continue to inflict skepticism on

current scholarship systems. Nevertheless, journals indexed by Scopus are now considered to be the elite journals in Indonesia. Either way, it is important to note the perplexing scenario in which the current Indonesian evaluation system seems explicitly designed to penalize Indonesian researchers who share and publish their work in the Indonesian language and Indonesian journals.

The access to the global literature appears on the decline when it was expected to increase in the era of a globalizing world and the World Wide Web. For example, Hedding[8] notes that researchers, and particularly students and non-academics (*i.e.* policy makers), in many poor countries from the Global South have increasingly limited access to papers behind paywalls. Thus, the ultimate goal of OA publishing should be to make research more accessible to researchers, students, and non-academics (*i.e.* policy makers)[8]. Although from a different perspective, the push for decolonization of research in South Africa has raised similar concerns[26]. Nordling[27] explains that decolonization is a movement to eliminate, or at least mitigate, the disproportionate legacy of white European thought and culture in education (including research). Although, Nordling[27] later notes the meaning of decolonization in the Natural Sciences is not well defined, and its relevance is even contested. Nevertheless, some South African researchers bemoan the lack of credit for publishing in local African journals[28]. This is even more true in other African countries (*e.g.,* Democratic Republic of Congo)[29]. As highlighted for Indonesia and as OA voices from the Global South (especially Brazil) have shown, green OA systems can be successful without capitulating to corporate publishers or expecting authors to pay high APC[30]. Although more recognition could be given

to African researchers publishing in African journals, the potential threat of predatory journals for African research communities is relatively high[21]. So, although a need exists for African researchers (and other researchers from least developed countries) to publish locally, this should be done while maintaining quality; which is the same problem that much of the rest of the world faces. To compound the problem in the case of the Earth Sciences community in Africa, very few local journals focus on Earth Sciences (e.g., *Journal of African Earth Science*, which is published by Elsevier and the OA options are virtually unaffordable for African researchers). These inequalities have led to inequities. Indeed, according to the DOAJ, around 71% of fully OA journals do not levy APCs but it does seem to be the case with only a few journals in Earth Sciences (e.g., *Geochemical Perspectives Letters*, *Volcanica*). Inherent bias of current APC-based OA publishing perpetuates this through the ”Matthew Effect”, ultimately reinforcing the journal-coupled prestige economy that currently governs our global research systems[17].

Conclusion

While being mindful of the major disparities described above, the most important thing is to conduct research and disseminate our science and information. We thus call for greater unification of the global Earth Sciences community to focus on non-profit and community-driven solutions for OA publishing and open science (*e.g.,* EarthArXiv). Indeed, the migration of EarthArXiv to a new infrastructure as a result of an emerging collaboration with California

Digital Library is a good opportunity to further highlight the need for not-for-profit and community-driven infrastructures for preprints repositories. It is time to return the sovereignty of research in the Earth Sciences to those who perform it and those who need it and, as reflected by the Earth Sciences community, there is a need to further engage in the ongoing discussion on the bibliodiversity manifesto.

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The authors declare no conflict of interest.

Authorship contributions

OP prepared the manuscript with contributions from all co-authors.

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