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Article

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Journal citation reports and the definition of a predatory journal: The case of the Multidisciplinary Digital Publishing Institute (MDPI)

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Abstract

The extent to which predatory journals can harm scientific practice increases as the numbers of such journals expand, in so far as they undermine scientific integrity, quality, and credibility, especially if those journals leak into prestigious databases. Clarivate's Journal Citation Reports (JCR), a reference for the assessment of researchers and for grant-making decisions, is used as a standard whitelist, in so far as the selectivity of a JCR-indexed journal adds a legitimacy of sorts to the articles that the journal publishes. The Multidisciplinary Digital Publishing Institute (MDPI) had 53 journals ranked in the 2018 JCRs annual report. These journals are analysed, not only to contrast the formal criteria for the identification of predatory journals, but taking a step further, their background is also analysed with regard to self-citations and the source of those self-citations in 2018 and 2019. The results showed that the self-citation rates increased and was very much higher than those of the leading journals in the JCR category. Besides, an increasingly high rate of citations from other MDPI-journals was observed. The formal criteria together with the analysis of the citation patterns of the 53 journals under analysis all suggest they may be predatory journals. Hence, specific recommendations are given to researchers, educational institutions and prestigious databases advising them to review their working relations with those sorts of journals.

Key words: predatory journals; journal citation reports; self-citation rate; citing journals; MDPI publisher.

Introduction

The journal Nature recently published a definition of the predatory journal (Grudniewicz et al. 2019), a milestone that highlights the increasing concern within academia of these pernicious journals that are exploiting the gold open-access publication model to their utmost, generating enormous financial gain 'which appears to be the main criteria for publication' (Frandsen 2017). Predatory journals, harmful to academia and science, 'sow confusion, promote shoddy scholarship and waste resources' (Grudniewicz et al. 2019) and therefore jeopardize integrity in science. Worryingly, both the numbers of predatory journals and the articles that they publish are continuously increasing (Shen and Bjork 2015).

In the gold open-access model, reading the publications is free and the publication costs, collected through the Article Processing Charge (APC), are incurred by the authors, their institutions, and funding bodies. A predatory journal will exploit this model to its own benefit with an inexistent or practically inexistent peer-review process (Beall 2015; Frandsen 2017; Demir 2018), which permits the rapid publication of academic papers without due guarantees, with an associated risk to the quality of the published science. At the same time, if there is a lack of awareness of predatory journals among scientists, then they will evaluate those publications as if they were legitimate and may naively send papers to predatory journals. At worst, however, authors may send them intentionally with the

double effect of 'polluting the scientific records and perversely advancing the careers of researchers' (Cortegiani et al. 2020).

Selective databases, such as Scopus, PubMed, and Journal Citation Reports (JCRs), form an index of journals, a sort of whitelist that is used for the purposes of assessing researchers and taking decisions on grant funding (Cortegiani et al. 2020; Siler 2020). However, some articles from some predatory journals are in fact indexed, both in PubMed (Manca et al. 2017a, b)—an alarmingly high number of them in the opinion of Manca et al. (2020)—and in Scopus (Hedding 2019; Cortegiani et al. 2020b). Their new found legitimacy means that any citations will, in consequence, raise the productivity metrics (e.g. h-index) of their authors, generating 'inflated curricula and doped academic careers' (Cortegiani, Manca and Giarratano, 2020a).

This investigation is centred on Clarivate's JCR, perhaps the most prestigious and best recognized database in academia with the widest use at a global level, in order to analyse the Multidisciplinary Digital Publishing Institute (MDPI). This mega-publisher appeared on Beall's list and was subsequently excluded. Moreover, the Norwegian Register for Scientific Journals, Series, and Publishers downgraded MDPI to 0 in 2019 and later upgraded it to 1 again. These facts suggest that MDPI has been open to question, a publisher that has been moving within a 'grey zone'. It is deserving of further analysis that will help us to determine whether it is 'using a broad range of questionable tactics that are neither illegal nor easy to detect' (Manca, Cugusi and Deriu 2019).

Against that backdrop, the objective of this study is to analyse the behaviour of 53 MDPI-journals that were JCR indexed in 2019, in order to elucidate whether these journals could be considered predatory. Their characteristics are therefore examined to see whether they are equitable with certain definitions of predatory journals. No longer merely a medium for dissemination, scientific journals are now a key foundation for appointments and funding in scientific research (Shu et al. 2018). The use of JCR has been extended, both for the evaluation of academics and institutions of all types, legitimizing the journals that are indexed, which evaluate the publications included in scholarly records when taking decisions on promotion, tenure, grants, etc. because it is used as a proxy for both quality and integrity. This analysis of the practices of MDPI is of relevance to researchers and for research institutions and funding bodies as well as for JCR itself, which could see its prestige compromised, if it incorporated predatory journals among its indexed journals.

Predatory journals

Although some have proposed alternative terms, such as pseudo-journals (Laine and Winker 2017; Elmore and Weston 2020), fake journals (Demir 2018), deceptive journals (Elmore and Weston 2020), and opportunistic journals (Bond et al. 2019), the term predatory journal is undoubtedly the most extensive in academia and appropriately describes this malpractice (Manca et al. 2020). The librarian, Jeffrey Beall, while at the University of Colorado and now in retirement, coined the term to identify journals that, overlooking quality peer-review processes, seek to generate income exclusively through the APCs that the authors are expected to pay and who are then sent misleading information on citation indexes and spam-related marketing (Beall 2012; Laine and Winker 2017).

Predatory journals are a global threat to science (Harvey and Weinstein 2017; Grudniewicz et al. 2019; Strong 2019), because they undermine its integrity (Vogel 2017; Abad-García 2019), its quality, and its credibility (Bond et al. 2019). They are, in all, a threat to society as a whole, because whenever the articles that they publish are indexed in selective databases, which is the case of PubMed, 'the items achieve global exposure and are interpreted by readers, including patients, as trustworthy' (Manca et al. 2019), with those articles likely not to have undergone an acceptable editorial and peer-review process. Cortegiani et al. (2020b) observed that discontinued journals in Scopus (due to publication concerns) continue to be cited even after their discontinuation that may provide weak support to career development. In addition, publication in a predatory journal implies the possible squandering of valuable resources: people, animals, and money, as Moher et al. (2017) have reminded us. Lastly, predatory journals are a threat to scientists who may endanger their careers and devalue their curricula.

The alarming increase in the number of predatory journals (from 1,800 to 8,000 over the period 2010–4) and the exponential growth (from 53,000 to 420,000 between 2010 and 2014) of the articles that they publish (Shen and Bjork 2015) have rendered futile any effort to keep white and blacklists updated. These lists very soon become outdated and incomplete, especially if the resources to keep them updated are scarce. Even so, the identification of predatory journals is still a crucial aspect in the maintenance of quality and scientific integrity. However, the reality is that this process is by no means simple, as Aromataris and Stern (2020) accurately indicated, particularly because 'predatory publishers have continued to evolve their undesirable art form into sophisticated operations that appear to be, at face value, legitimate' to the point where 'certain journals and publishers may blatantly exploit "gray" strategies given that downmarket niches can be lucrative' (Siler 2020).

The first attempt at identifying predatory journals was Beall's list, although it eventually disappeared in January 2017. Given the immense difficulties of keeping a list of predatory journals updated, the use of one from among the very many abundant checklists, such as 'Think.Check.Submit' (https://thinkchecksubmit.org/), is encouraged[1]. Likewise, Cabells' blacklist and whitelist, now referred to as predatory journals and analytics https://blog.cabells.com/2020/06/08/announcement/, listed more than 12,000 predatory journals in October 2019 (https://blog.cabells.com/2019/10/02/the-journal-blacklist-surpasses-the-12000-journals-listed-mark/). Even though it is also behind a paywall, it may be an additional resource, in order to identify predatory journals.

In any case, the first step towards identifying predatory journals is to have a clear definition for their definitive identification. The potential criteria for the identification of a predatory journal and a list of suspicious items are lengthy: journal names may be very similar to prestigious journals; the web page may contain spelling errors and questionable grammatical constructions and/or low quality images; the language on the journal webpage may resemble a 'hard sell' that targets academic authors; the journal may include articles outside its stated scope or may have a very broad scope; submission can be by email instead of a manuscript management system; the editor-in-chief might also act as the editor-in-chief of another journal with a widely different scope, predominance of editorial board members from developing countries; time-lines for publication and fast-track peer-review processes might appear unrealistic; APCs can be low; impact-factor metrics may be unknown; spam emails may invite academics to submit papers; despite the open-access approach, transfer of copyright may be required; and, finally, non-professional or non-journal affiliated contact information may be given

for the editorial office (Manca et al. 2018; Committee on Publication Ethics 2019; Gades and Toth 2019; Kisely 2019; Vakil 2019; Elmore and Weston 2020; Kratochvíl et al. 2020).

The problem is that each of these criteria, above all if taken in an isolated way, are questionable and may occur singly or together in non-predatory journals. For example, the APC can be higher than 1,000 USD (as happens for OMICS), there is no specific limit to the number of editorial board members from developing countries that is considered a proper way of distinguishing between legitimate and predatory journals, the content of the web page can appear suspect, and titles may inevitably be mimicked when the journal specialism is very narrow (Kratochvíl et al. 2020).

It is therefore essential to define the concept not to solely rely on specific criteria. The Committee on Publication Ethics (COPE) (2019) clarified that predatory publishing 'generally refers to the systematic for-profit publication of purportedly scholarly content (in journals and articles, monographs, books, or conference proceedings) in a deceptive or fraudulent way and without any regard for quality assurance [... so] these journals exist solely for profit without any commitment to publication ethics or integrity of any kind'.

The COPE definition of predatory journals is no different in essence to the definition of Grudniewicz et al. (2019): 'predatory journals and publishers are entities that prioritize self-interest at the expense of scholarship and are characterized by false or misleading information, deviation from best editorial and publication practices, a lack of transparency, and/or the use of aggressive and indiscriminate solicitation practices'. It should be pointed out that, despite the significant advance in the definition proposed by Grudniewicz et al. (2019), so as to recognize predatory journals (and not to fall prey to them), it nevertheless omits an express reference to the quality of peer revision. In spite of its important role in science, it was considered too subjective an aspect—partly because, as with journal quality and deceitfulness, it is impossible to assess—(Grudniewicz et al. 2019; Cukier et al. 2020) for inclusion in an objective definition.

Multidisciplinary DIGITAL publishing institute (MDPI)

The MDPI, with its headquarters in Basel (Switzerland), formerly known as Molecular Diversity Preservation International (https://www.mdpi.com/about/history) that launched its first two journals (Molecules and Mathematical and Computational Applications) in 1996, operates a gold open- access framework. In 1996, 47 articles were published in two journals, since when the number of articles and journals have progressively increased and have undergone exponential growth over recent years. By 2019, 106,152 articles had been published in its 218 journals, an increase of 64.1% over 2018. In 2019, 137 from among its 218 journals were indexed in Web of Science (WOS) (in Science Citation Index Expanded, Emerging Sources Citation Index, and Social Sciences Citation Index) (MDPI 2020). Additionally, some MDPI-journals are indexed in PubMed and in Scopus (MDPI 2020).

According to the MDPI Annual Report 2019 (MDPI 2020), these 218 journals are supported by 67,207 editors (an increase of 55.78% over 2018) with a median time from submission to publication of 39 days (as it was in 2018) and APCs ranging from 300 to 2,000 CHF (1 Swiss Franc is approximately equal to 0.92 Euros) with a median of 1.525 CHF. MDPI founder and current president is Shu-Kun Lin, Ph.D (https://www.mdpi.com/about/team).

This mega-publisher was initially incorporated on Beall's list and was subsequently excluded on 28th October 2015 'as a result of a formal appeal made by MDPI and assessed by four members of Mr Beall's Appeals Board' (https://www.mdpi.com/about/announcements/534). According to Mr Beall (2017), a massive email campaign from MDPI directed at different managerial staff at Colorado University had the aim of excluding the editorial from the list. Besides, the Norwegian Register for Scientific Journals, Series and Publishers—jointly operated by The National Board of Scholarly Publishing and the Norwegian Centre for Research Data (NSD)— in the framework of the NSD downgraded MDPI to 0 over various months in 2019 and later upgraded to 1 again[2]. (https://dbh.nsd.uib.no/publiseringskanaler/KanalForlagInfo.action?id=26778andbibsys=false).

Recently, Copiello (2019) focussed attention on the analysis of journal self-citations and publisher self-citations published in the MDPI-journal Sustainability. This may suggest a form of post-production misconduct, due to the manipulation of citations, which affects the impact factor of the journal, its visibility and its influence. He demonstrated that the self-citations of Sustainability, in 2016 and 2017, in relation to articles published in 2015, in no way corresponded to a uniform probability distribution.

It may therefore be appreciated that the reputation of MDPI Publisher has undergone ups and downs over the past few years and has both its critics and supporters, which makes it an interesting case study. The aim of this investigation is to assess whether the subset of MDPI-journals that are indexed in JCR fit various criteria used in some definitions of a predatory journal.

Methodology

Grudniewicz et al. (2019) state that predatory journals prioritize self-interest at the expense of scholarship and that their behaviour includes "deviation from best editorial and publication practices". The strategies of any journal are not made public in such a way that their interests and objectives can be objectively evaluated. However, the Principles for Transparency and Best practices in Scholarly Publishing of COPE (2019) may well serve as a reference to evaluate journal behavior, particularly with reference to their disregard of quality assurance.

As indicators of their objectives and strategy, this study analysed journals' behavior in relation to the following measures: similarity of journal name, content output, APCs, frequency of publication, editorial board size, peer review process (particularly peer review time as peer review is the most common procedure to assure published manuscript quality), journal Impact Factor, and self-citation (due to its direct impact on journals' reputation metrics). The list of criteria was created after considering which information could be objectively collected and compared across journals and which may fit the suggestion by the above sources that predatory journals do not follow best publication practices.

Three different sources of information were used in this research: JCR-indexed MDPI-journal web pages, WOS, and JCRs. Data were collected between 2 December 2019 and 4 January 2020. JCR-indexed MDPI-journals (edition 2018, released 2019) were selected for the analysis (53 out of 218). As a control group for comparison with JCR-indexed MDPI-journals, the top ranked journal by Impact Factor in each relevant subject category were selected (all under the joint name of non-MDPI-journals in this study) (Table 1).

Data on each selected journal were gathered from the following sections of the MDPI-journal web pages: Home, Editorial Board,

Table 1. JCR-indexed MDPI-journals in (2018) and ranking/leading journal in the category

JOURNAL NAME/leading journal	Q	JOURNAL NAME/leading journal	Q
Agronomy/*Annual Review of Plant Biology*	Q1	Marine Drugs/*Natural Product Reports*	Q1
Animals/*Annual Review of Animals Biosciences*	Q1	Materials/*Nature Review Materials*	Q2
Antibiotics/*Nature Reviews Drugs Discovery*	Q2	Mathematics/*Acta Numerica*	Q1
Antioxidants/*Cell*	Q1	Medicina/*New England Journal of Medicine*	Q3
Applied Sciences/*Nature Reviews Materials*	Q2	Metabolites/*Cell*	Q2
Atmosphere/*Nature Climate Change*	Q3	Metals/*Nature Reviews Materials*	Q1
Biomolecules/*Cell*	Q1	Micromachines/*Nature Reviews Materials*	Q2
Brain Sciences/*Nature Reviews Neurosciences*	Q3	Microorganisms/*Nature Reviews Microbiology*	Q2
Cancers/*CA-A Cancer Journal for Clinicians*	Q1	Minerals/*International Journal of Rock Mechanisms and Mining Science*	Q2
Catalysts/*Nature Materials*	Q2	Molecules/*Chemical Reviews*	Q2
Cells/*Nature Reviews Molecular Cell Biology*	Q1	Nanomaterials/*Nature Reviews Materials*	Q1
Coatings/*Applied Surface Science*	Q2	Nutrients/*Progress in Lipid Research*	Q1
Crystals/*Nature Reviews Materials*	Q2	Pathogens/*Nature Reviews Microbiology*	Q2
Diagnostics/*New England Journal of Medicine*	Q2	Pharmaceutics/*Nature Reviews Drugs Discovery*	Q1
Diversity/*Trends in Ecology and Evolution*	Q3	Plants/*Annual Review of Plant Biology*	Q2
Electronics/*IEEE Transactions on Pattern Analysis and Machine Intelligence*	Q3	Polymers/*Progress in Polymer Science*	Q1
Energies/*Nature Energy*	Q3	Processes/*Energy and Environmental Science*	Q2
Entropy/*Reviews of Modern Physics*	Q2	Remote Sensing/*IEEE Geoscience and Remote Sensing Magazine*	Q1
Foods/*Comprehensive Reviews in Food Science*	Q2	Sensors/*ACS Energy Letters*	Q1
Forests/*Agricultural and Forest Meteorology*	Q2	Symmetry/*Nature*	Q2
Genes/*Nature Reviews Genetics*	Q2	Sustainability/*Energy and Environmental Science*	Q2
International Journal of Environmental Research and Public Health (IJERPH)/*Energy and Environmental Science*	Q1	Toxins/*Annual Review of Pharmacology and Toxicology*	Q1
ISPRS International Journal of Geo-Information (IJGI)/*IEEE Geoscience and Remote Sensing Magazine*	Q3	Universe/*Annual Review of Astronomy and Astrophysics*	Q2
International Journal of Molecular Sciences (IJMS)/*Chemical Reviews*	Q2	Vaccines/*Nature Reviews Immunology*	Q1
Insects/*Annual Review of Entomology*	Q1	Viruses/*Cell Host and Microbe*	Q2
Journal of Clinical Medicine (JCM)/*New England Journal of Medicine*	Q1	Water/*Water Research*	Q2
Journal of Marine Science and Engineering (JMSE)/*Annual Review of Marine Science*	Q3		

Note: When a JCR-indexed journal is ranked in more than one category, 1 its highest rank is depicted in column Q; 2 the leading journal for comparison is the one with the highest impact factor (2018) in the category where the MDPI-journal is ranked.

Special Issues, APC, and Journal Statistics. Besides, data were collected from JCR (2018) on the Journal Impact Factor and the Impact Factor Without Self Cites. Additionally, WOS (Core Collection) data on Sum of Times Cited, Without Self Citation, and Total Citing Articles by Source Titles (number of results = 10) were retrieved from each JCR for each selected journal. Exceptionally, data on the MDPI-journal self-citation rates were collected on 3 June 2020, to assure data accuracy in relation to the 2019 self-citation rates.

Citation analysis used for citation manipulation is a form of misconduct and does not fit best editorial practices (a feature of predatory journals mentioned in Grudniewicz et al.'s (2019) definition.

The same information was collected from journal web pages, WOS (Core Collection) and JCR for leading journals in each JCR category where the MDPI-journals were indexed. In some cases, where an MDPI-journal was indexed in more than one JCR category, the non-MDPI-journal with the highest impact factor was chosen for comparison.

Results

There were 53 MDPI-indexed journals in the JCR (2018), 20 of which were ranked Q1, 25 were ranked Q2, and only 8 were ranked Q3 (see Table 1).

Similarity of journal name

The first relevant fact of their analysis is that some journals use very similar names to other journals with established reputations, which can be one of the characteristics of predatory journals, with which they could be seen to prey upon those less well informed on the subject of predatory journals (Xia et al. 2015; Beall 2016; Alrawadieh 2020). Some examples of the MDPI-journals with names similar to other journals are Cells, Cancers, Polymers, Remote Sensing, Animals and Genes, which seem remarkably similar to other journals established earlier and edited by Elsevier (Cell, Polymer, Gene, Remote Sensing of Environment), Wiley (Cancer), and Cambridge University Press (Animal).

Content output

As shown in Figure 1, the number of articles published in 2019 in each journal varied highly, ranging from 226 in Vaccines to 7,414 in Sustainability. Globally, the total number of articles published in 2019 by the 53 MDPI-journals under analysis was 93,240, representing a global increase of 74.95% in 2018. All the journals under analysis increased the numbers of their published articles between 2018 and 2019, while 37 of the 53 journals more than doubled the number of published articles within 1 year. The increase in the number of published articles between 2018 and 2019 ranged from 554.91% in Medicina to 18.3% in the ISPRS International Journal of Geo-Information (IJGI). The average increase in the number of published articles was 148.93%.

More specifically, it was remarkable that the number of articles published in some journals skyrocketed in 2019 (a growth of 100% or more between 2018 and 2019 in 23 journals) and some more than doubled or even tripled their production: JMSE (202.5%), Metabolites (228.57%), Electronics (229.66%), Foods (231.48%), Mathematics (239.13%), Antioxidants (240%), Pathogens (253.68%), Processes (254.28%), Cancers (280.25%), JCM (287.77%), Animals (391.2%), Biomolecules (391.7%), Plants (463.24%), Microorganisms (486.36%), Cells (498.97), and Medicina (554.91%). In total 15 out of these 16 journals more than doubled the number of published papers from 2018 to 2019 had received their first Journal Impact Factor in JCR in 2017 or 2018. A review of content output in the leading journals was not conducted.

APCs

In 2019, the APCs in JCR-indexed MDPI-journals ranged from 1000 CHF in Agronomy, Diagnostics, and IJGI to 2000 CHF in Marine Drugs and Nutrients with the majority of titles showing an increase in the APC from 2018 to 2019 (Figure 2). The APCs published on the journal web pages of the 53 journals under analysis imply that the articles published in 2019 could have generated an approximate income of 153,834,500 CHF (no APC-related waiver or discount could be considered in this calculation as no JCR-indexed journal provides relevant detailed information on the topic). A review of APCs for the leading journal control group was not conducted.

Frequency of publication

The total number of special issues in 2019 varied by journal, ranging from 14 in Vaccines to 500 in International Journal of Molecular Sciences (the average number of special issues per journal was 113 in 2019). As with the number of published articles, the number of special issues for all journals between 2018 and 2019 increased, in such an exorbitant manner that the number of special issues in the MDPI-journals under analysis was easily higher, in the majority of cases, than the number of ordinary issues of 53 MDPI journals analysed since 98.11% of 53 analysed journals published 12 or fewer issues per year in 2018 (data from JCR 2019 edition). The number of special issues was over twice the number of ordinary issues in 92.45% of the MDPI-journals under analysis. Moreover, in January 2020, the number of special issues scheduled for 2020 with respect to those in 2019 skyrocketed in all the journals under study to levels as surprisingly high as 788 special issues in Sustainability, 830 in Applied Sciences, and 846 in Materials. From December 2019 to January 2020, almost all MDPI-journals (94.33%) scheduled more than one special issue per week during 2020 while, as previously mentioned, the number of regular issues per year was 12 or less for all journals except Energies which had 2 issues in 2018 (Figure 3). A review of the frequency of special issue publication in the control group was not conducted.

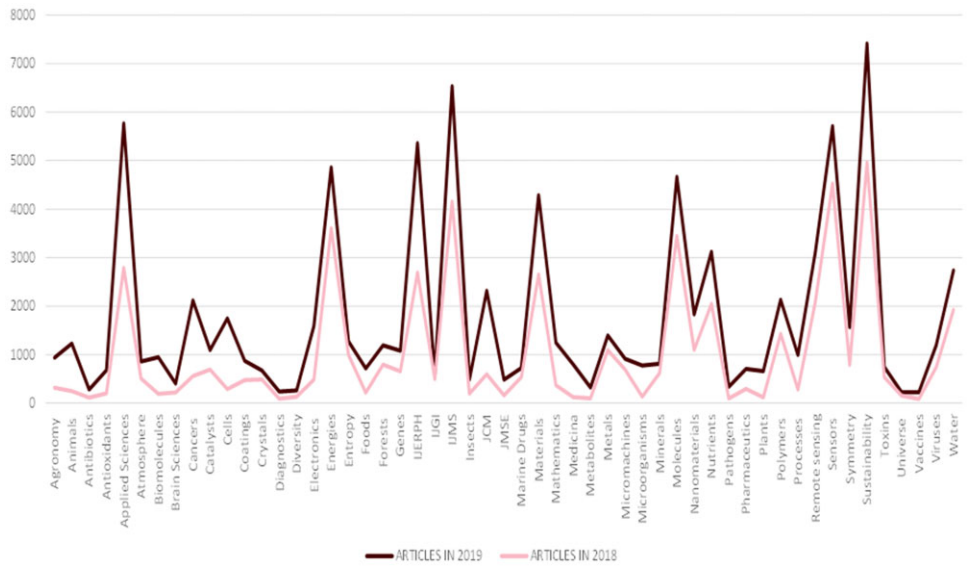

Figure 1. Number of articles published by MDPI-journals (2018 and 2019).

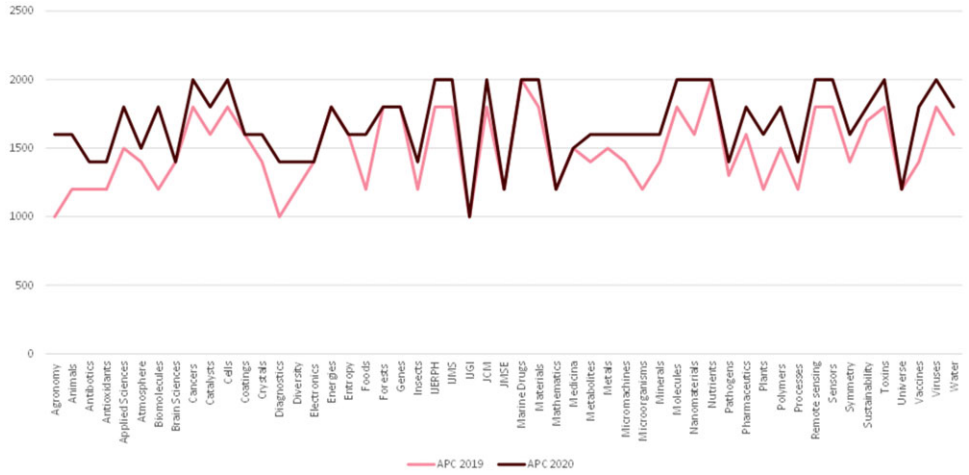

Figure 2. APC of MDPI-journals (2019 and 2020).

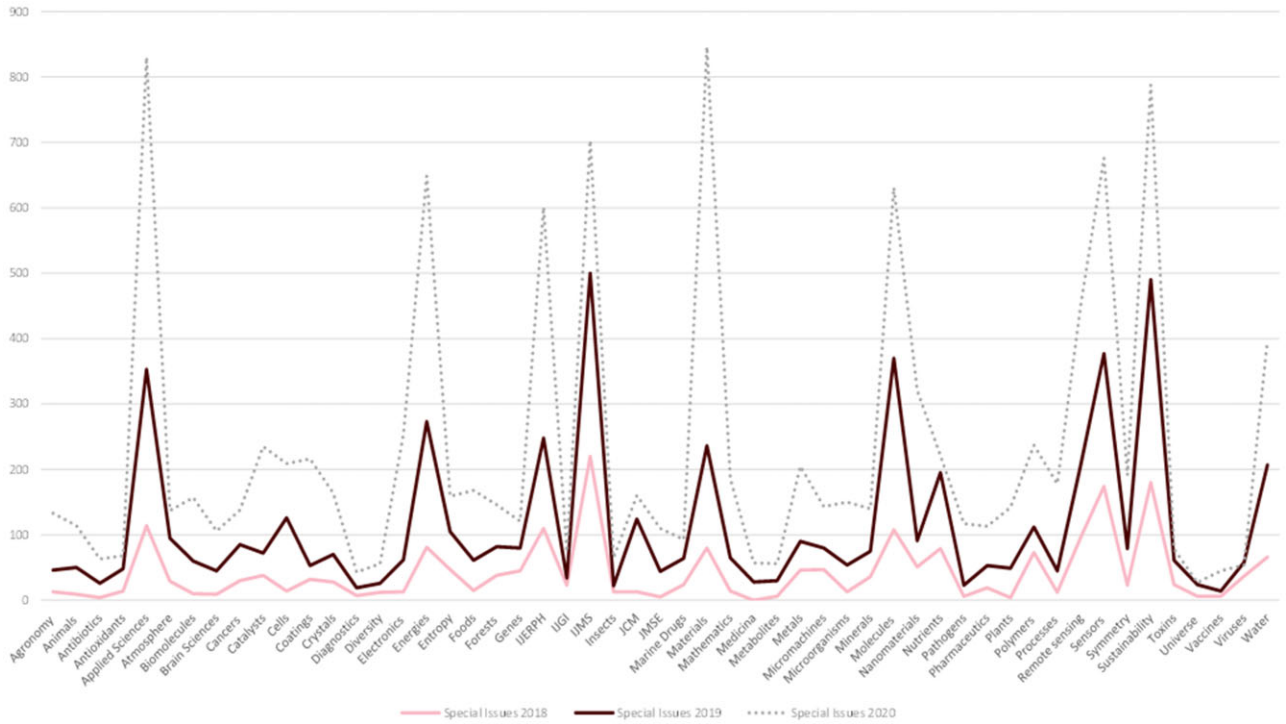

Figure 3. Number of special issues of MDPI-journals (2018, 2019 and 2020).

Size of Editorial Board

A further relevant aspect worth focussing upon is the size of the Journal Editorial Board. The journal Sustainability has the largest Editorial Board with 1,145 members, while the journal Metabolites has a mere 62 Editorial Board members. It is interesting to note that the size of the Editorial Board was, in all cases, larger in the MDPI-journals than in the leading JCR-indexed journals belonging to the same categories (Table 2).

Peer review process

The following analysis addressed the peer-review process. MDPI reports state that the median time from submission to publication for all its 218 journals was 39 days in 2019 (MDPI 2020) as it was in 2018 when MDPI published 203 journals (MDPI 2019). Unfortunately, there is no information available on the time from submission to the final decision for the 53 journals under analysis, only minimum and maximum times from submission to first decision, as shown in Figure 4.

More specifically, in general terms, the average time from submission to first decision from MDPI-journals was 19 days, both in 2019 and 2018 (MDPI 2020), despite the increase in the number of both journals (15 new journals from 2018) and articles which were published (a 64.1% increase compared to 2018). Focussing our attention on the 53 MDPI-journals under analysis, 84.9% of their websites reported that they provided a first decision within <19 days. As shown

Table 2. JCR-indexed MDPI-journals (2018)/leading journal in the category. Editorial Board size and self-citation rates (2018, 2019)

Journal name/leading journal	Editorial Board size		Self-citation rate 2018		Self-citation rate 2019	
Agronomy/*Annual Review of Plant Biology*	224	*5*	5.71	*0.16*	18.99	*0.78*
Animals/*Annual Review of Animal Biosciences*	284	*7*	11.49	*1.42*	22.00	*1.51*
Antibiotics/*Nature Reviews Drugs Discovery*	130	*6*	3.58	*1.1*	14.69	*1.69*
Antioxidants/*Cell*	117	*107*	5.68	*1.31*	16.55	*5.28*
Applied Sciences/*Nature Reviews Materials*	892	*0*	7.35	*0.35*	19.46	*0.27*
Atmosphere/*Nature Climate Change*	194	*0*	8.34	*2*	20.12	*12.67*
Biomolecules/*Cell*	224	*107*	3.86	*1.28*	7.05	*5.28*
Brain Sciences/*Nature Reviews Neurosciences*	122	*0*	7.73	*0.58*	10.51	*2.21*
Cancers/*CA-A Cancer Journal for Clinicians*	442	*13*	2.98	*0.15*	12.95	*1.04*
Catalysts/*Nature Materials*	188	*8*	7.64	*1.15*	12.77	*7.45*
Cells/*Nature Reviews Molecular Cell Biology*	354	*0*	2.54	*0.85*	9.32	*1.55*
Coatings/*Applied Surface Science*	222	*28*	7.91	*2.34*	17.24	*9.7*
Crystals/*Nature Reviews Materials*	263	*0*	9.82	*0.34*	20.07	*0.27*
Diagnostics/*New England Journal of Medicine*	97	*15*	4.69	*1.35*	13.38	*6.21*
Diversity/*Trends in Ecology and Evolution*	128	*25*	9.45	*2.31*	14.73	*9.06*
Electronics/*IEEE Transactions on Pattern Analysis and Machine Intelligence*	206	*0*	10.56	*0.65*	27.46	*0.82*
Energies/*Nature Energy*	468	*11*	16.79	*0.92*	24.17	*6.29*
Entropy/*Reviews of Modern Physics*	222	*14*	12.01	*0.13*	21.84	*0*
Foods/*Comprehensive Reviews in Food Science*	112	*6*	5.27	*0.86*	14.85	*7.35*
Forests/*Agricultural and Forest Meteorology*	271	*69*	9.64	*2.35*	19.74	*7.74*
Genes/*Nature Reviews Genetics*	292	*0*	3.35	*0.64*	10.18	*4.28*
International Journal of Environmental Research and Public Health (IJERPH)/*Energy and Environmental Science*	804	*9*	9.85	*0.62*	19.05	*2.82*
ISPRS International Journal of Geo-Information (IJGI)/*IEEE Geoscience and Remote Sensing Magazine*	105	*0*	9.47	*2.66*	19.52	*0*
International Journal of Molecular Sciences (IJMS)/*Chemical Reviews*	1,113	*8*	25.54	*0.37*	10.01	*0.87*
Insects/*Annual Review of Entomology*	128	*6*	2.16	*0*	16.89	*0*
Journal of Clinical Medicine (JCM)/*New England Journal of Medicine*	310	*15*	2.79	*0.88*	10.52	*6.21*
Journal of Marine Science and Engineering (JMSE)/*Annual Review of Marine Science*	246	*9*	13.33	*0.33*	20.60	*0.68*
Marine Drugs/*Natural Product Reports*	176	*11*	6.93	*0.79*	16.34	*4.49*
Materials/*Nature Review Materials*	449	*0*	8.35	*0.34*	15.43	*0.27*
Mathematics/*Acta Numerica*	117	*12*	8.28	*0*	15.18	*0*
Medicina/*New England Journal of Medicine*	152	*15*	2.63	*1.35*	7.14	*6.21*
Metabolites/*Cell*	62	*107*	3.56	*1.28*	8.33	*5.28*
Metals/*Nature Reviews Materials*	225	*0*	13.37	*0.34*	22.78	*0.27*
Micromachines/*Nature Reviews Materials*	194	*0*	11.89	*0.34*	20.06	*0.27*
Microorganisms/*Nature Reviews Microbiology*	266	*0*	2.48	*0.23*	10.18	*3.97*
Minerals/*International Journal of Rock Mechanisms and Mining Science*	193	*0*	10.75	*12.98*	26.15	*7.05*
Molecules/*Chemical Reviews*	1,019	*8*	5.11	*0.37*	10.07	*0.87*
Nanomaterials/*Nature Reviews Materials*	288	*0*	5.63	*0.34*	11.91	*0.27*
Nutrients/*Progress in Lipid Research*	301	*14*	6.46	*0*	17.46	*2.73*
Pathogens/*Nature Reviews Microbiology*	163	*0*	0.67	*0.23*	3.84	*3.97*
Pharmaceutics/*Nature Reviews Drugs Discovery*	136	*6*	3.7	*1.08*	11.50	*1.69*
Plants/*Annual Review of Plant Biology*	291	*5*	1.49	*0.16*	9.78	*0.78*
Polymers/*Progress in Polymer Science*	332	*30*	6.17	*0.06*	17.14	*0.74*
Processes/*Energy and Environmental Science*	77	*9*	10.24	*0.6*	23.06	*2.82*
Remote Sensing/*IEEE Geoscience and Remote Sensing Magazine*	600	*0*	10.74	*2.85*	23.78	*0*
Sensors/*ACS Energy Letters*	991	*34*	9.73	*2.42*	20.20	*9.9*
Symmetry/*Nature*	135	*33*	9.34	*0.62*	12.64	*7.26*
Sustainability/*Energy and Environmental Science*	1,145	*9*	18.58	*1.6*	27.69	*2.8*
Toxins/*Annual Review of Pharmacology and Toxicology*	95	*7*	7.48	*2.84*	14.63	*10.52*
Universe/*Annual Review of Astronomy and Astrophysics*	131	*7*	2.6	*0*	5.36	*2.38*
Vaccines/*Nature Reviews Immunology*	142	*3*	4.9	*0.49*	7.6	*1.08*
Viruses/*Cell Host and Microbe*	90	*33*	6.36	*2.93*	15.20	*14.28*
Water/*Water Research*	295	*46*	12.79	*1.87*	22.57	*9.05*

Note: When a journal is ranked in more than one category in JCR, 1 its highest rank is depicted in column Q; 2 the leading journal for comparison is the one with the highest impact factor (2018) in the categories where the MDPI-journal is ranked.

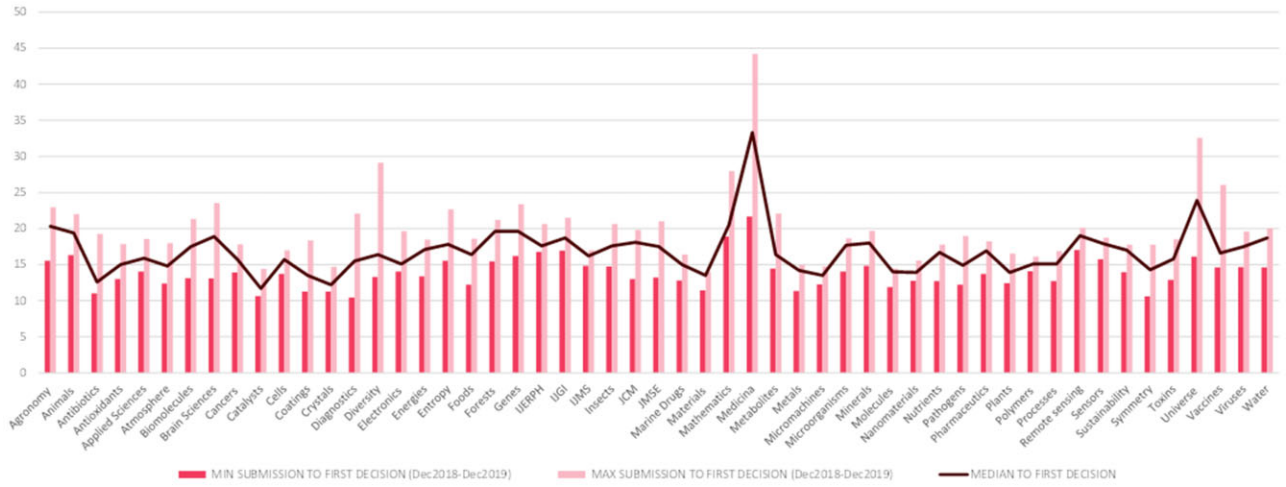

Figure 4. Days from submission to first decision (median, minimum and maximum) of MDPI-journals.

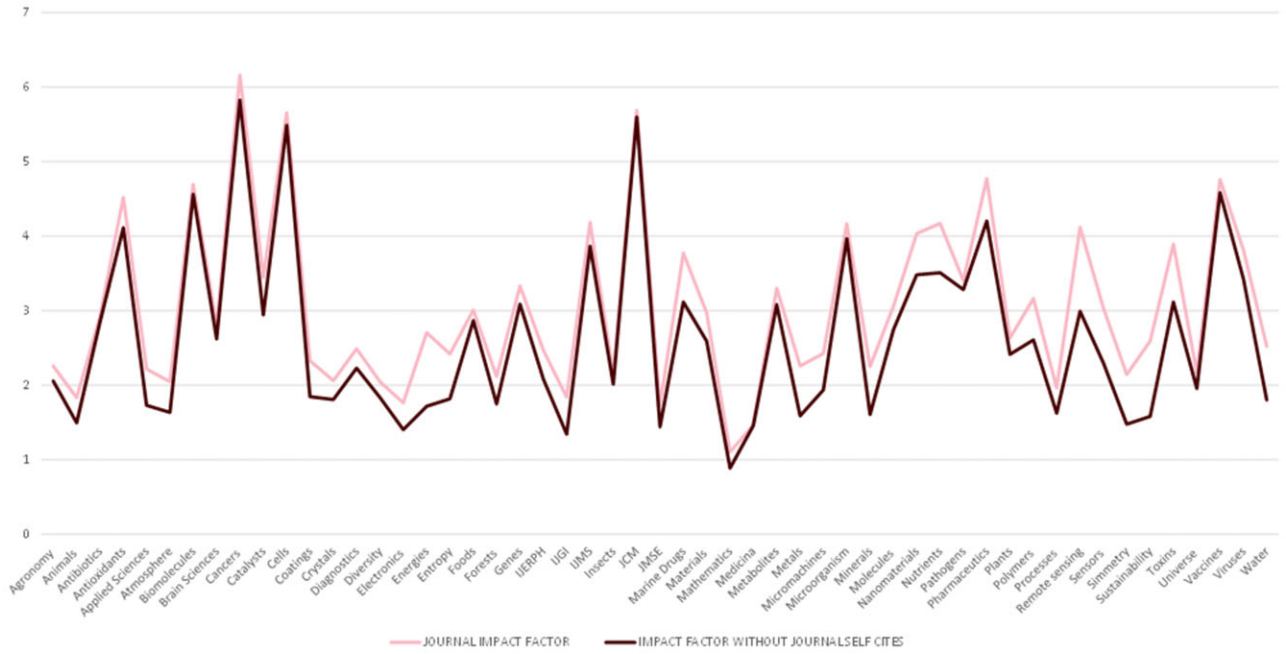

Figure 5. Journal impact factors of MDPI-journals with and without self-citations (2018).

in Figure 4, the minimum for most journals (77.35%) was <15 days from submission to the first decision and the maximum was under 22 days. The number of articles published during 2019 appeared to have no effect on the average duration of peer review. For example, Sustainability published a total of 7,414 articles in 2019, with peer-review periods of between 13.94 and 17.75 days from submission to first review, while Vaccines published 226 articles in 2019 with peer-review periods ranging between 14.61 and 26.04 days.

Journal impact factor and self-citations

As depicted in Figure 5, the impact factors of all journals were reduced when self-citations were removed. The drop in the impact factor ranged between 38.96% in the case of Sustainability to 0.68% in Medicina with an average reduction of 14.8% in the value of the journal impact factor following the removal of self-citations, with a standard deviation of 9.31 (Figure 5).

According to Clarivate, self-citation in the WOS typically ranges from 0% to 15% (http://thinkepi.net/notas/crecs_2017/J_9_45_Cahue.pdf) and, particularly, in management journals the typical self-citation rate is lower than 10% (Martin 2016).

In 2019, 24 journals out of 53 had self-citation rates as high as 15%, which is the upper end of the normal range set by Clarivate (Table 2). Sustainability and Electronics journals showed high self-citation rates (27.69% and 27.46%, respectively) followed by Minerals (26.15%). All journals, except the International Journal of Molecular Science, increased self-citation rates between 2018 and 2019 (between 2.7 and 16.9 points).

Certainly, all journals have a level of self-citation, as previously mentioned, and therefore virtually all of them showed a reduction in

the journal impact factor without self-citations when compared to the journal impact factor. A contextual framework is therefore required to assess MDPI-journal self-citations. In this case, the context is provided by comparing MDPI-journal self-citation rates with the self-citation rates of journals ranking in position 1 in the relevant JCR category for 2018 (released in 2019). Where an MDPI-journal was ranked in more than one category, the leading journal with a higher impact factor in those categories in 2018 was selected for comparison (Table 2).

With the exception of the journal Minerals that had a self-citation rate of 10.75% in 2018, compared to 12.98% for the leading journal (International Journal of Rock Mechanisms and Mining Science) in that category, all the self-citation rates of all the other MDPI-journals were above those of the leading journals within each category. In 2018, the case of the International Journal of Molecular Sciences and Sustainability, with self-citation rates several times higher than those of the leading journals within the same category stands out (a difference of 25.17% and 16.98%, respectively).

The high rate of self-citations of the journal Sustainability is coherent with data that the journal itself provided in its bibliometric review over the period 2009–18 (https://www.mdpi.com/2071-1050/10/5/1655), showing that Sustainability ranks first in citing journals (2,496 cites) very much over the Journal of Cleaner Production that occupies second position (658 cites) in this bibliographic review. It is remarkable that in the aforementioned bibliometric study over the period 2009–18, the first 30 positions in the citation ranking were occupied by journals from the same publisher (#3 Energies, #8 Water, #23 International Journal of Environmental Research and Public Health, #24 Remote Sensing and #30 IJGI). Copiello (2019) also analysed the citations and self-citations of articles published in the journal Sustainability in 2015 and found that the journal had a higher self-citation level than expected.

Shedding further light on MDPI-journal citing sources, the top 10 MDPI journals for citations listed on the WOS were analysed and intra-MDPI citation levels were identified with other MDPI-journals. In 2019, almost all 53 MDPI-journals under analysis had intra-MDPI citation rates well above 20% (all except Universe—11.87%— and Catalysts—18.73%—), reaching values as high as 56.94% in Electronics, 51.07% in the IJGI, 47.56% in Remote Sensing, and 46.55% in Sustainability (Table 3).

If our attention is focussed on the intra-MDPI citation rate trends between 2018 and 2019, we see that 46 out of the 53 journals increased their intra-MDPI citation rates. However, the seven journals that never did (Sustainability, Mathematics, International Journal of Molecular Sciences, Symmetry, Applied Sciences, Micromachines, and Catalysts) had intra-MDPI citation rates above 15%, ranging from 18.73% in Catalysts to 46.55% in Sustainability (Table 3).

Table 3. Intra-MDPI citation rate 2018 and 2019 (top 10 citing journals)

Journal name	2018	2019	Journal name	2018	2019
Agronomy	30.6	44.64	Marine Drugs	32.05	33.39
Animals	34.43	41.91	Materials	23.7	33.17
Antibiotics	13.97	22.91	Mathematics	39.54	31.92
Antioxidants	21.42	37.46	Medicina	20.35	28.14
Applied Sciences	37.83	36.65	Metabolites	16.14	21.87
Atmosphere	24.81	39.88	Metals	35.69	41.86
Biomolecules	17.68	24.17	Micromachines	30.78	30.61
Brain Sciences	11.77	22.19	Microorganisms	12.88	29.12
Cancers	19.02	23.42	Minerals	28.14	35.08
Catalysts	18.9	18.73	Molecules/	14.41	22.71
Cells	20.46	22.19	Nanomaterials	19.98	21.09
Coatings	29.00	39.98	Nutrients	26.41	32.74
Crystals	16.28	26.28	Pathogens	1.53	24.32
Diagnostics	11.24	30.65	Pharmaceutics	18.82	30.92
Diversity	14.18	20.85	Plants	22.31	34.64
Electronics	55.1	56.94	Polymers	24.42	29.67
Energies	41.72	42.38	Processes	32.92	33.8
Entropy	32.82	34.04	Remote Sensing	38.26	47.56
Foods	20.39	30.7	Sensors	33.6	38.65
Forests	33.63	38.74	Symmetry	36.21	32.86
Genes	15.5	20.36	Sustainability	57.53	46.55
IJERPH	26.9	33.46	Toxins	25.11	31.71
IJGI	42.45	51.07	Universe	9.23	11.87
IJMS	28.96	22.22	Vaccines	9.29	29.64
Insects	16.11	25.59	Viruses	18.29	22.86
JCM	21.88	24.13	Water	38.55	39.35
JMSE	31.8	41.58			

IJERPH, International Journal of Environmental Research and Public Health; IJGI, ISPRS International Journal of Geo-Information; IJMS, International Journal of Molecular Sciences; JCM, Journal of Clinical Medicine; JMSE, Journal of Marine Science and Engineering.

Discussion

Similarity of journal names

As Manca et al. (2020) highlight, publishers could not explain not following best practices since there are settled by the industry principles for transparency and best practices in scholarly publishing. The Committee on Publication Ethics (COPE) released the Principles of Transparency and Best Practices in Scholarly Publishing (last version published 15 January 2018) together with the Directory of Open-Access Journals (DOAJ), the Open-Access Scholarly Publishers Association (OASPA), and the World Association of Medical Editors (WAME). Therefore, these Principles, supported by different institutions, are useful for detecting deviation from best practices in publishing.

Regarding journal names, aforementioned Principles state they "shall be unique and not be one that is easily confused with other journal or might mislead potential authors and readers about the journal's origin or association with other journals". However, as previously shown, some MDPI journals' name are very similar to other publishers journals breaching the required condition of not been easily confused with another journal.

APCs

The APC in JCR-indexed MDPI-journals (from 1000CHF to 2000 CHF) needs to be contextualized. It is difficult however to contextualize the analysis of APC in JCR-indexed MDPI journals for two reasons. First, a proper systematic and structured overview of APC rates it is not available. Second, only limited insights are possible because not all the journals in the control group are in the framework of gold open access (which would allow a direct comparison). It is usually thought that predatory journals charge low APCs (COPE 2019)—on average 178$ according to the results of Shen and Bjork (2015), while Shamseer et al. (2017) warned researchers from the biomedical field that APCs lower than 150$ were suspect. However, significant differences have been found between large publishers

(publishing more than 100 journals) that charge an average fee of 796$ and the publishers of a single journal that charge an average fee of 83$ (Shen and Bjork, 2015).

More specifically, the case of the mega-publisher OMICS International is well known, which publishes 700 different journals and has been ordered to pay 50.1 million USD in damages in the USA 'for deceiving thousands of authors who published in its journals and attended its conferences' (Brainard 2019). Its average APC amounts to 1,138USD (OMICS 2020). Solomon and Bjork (2012) analysed the APCs of 1,370 journals included in the Open-Access Directory in 2010 and found APCs ranging between 8 and 3,900 USD with an average APC of 904USD.

The increase in APCs was qualified as hyperinflation by Khoo (2019) and was not exclusive to MDPI, as in his study, which covered 319 journals of the four-largest APC-funded open-access publishers—Hindawi, Frontiers, MDPI, and BioMed Central Ltd. (BMC)—between 2012 and 2018, he found overall APC rises in all of them ranging between 17% and 220% and, likewise, observed a rise in the number of articles per journal.

Content output

In JCR-indexed MDPI-journals, if the trend of increasing numbers of published articles in all journals continues into 2020 and taking into account the generalized rise in the APC for 2020, MDPI may reasonably expect to see a rise in its income in 2020. It is commonly observed that, after getting its first impact journal, journals increase the number of submissions and, depending on acceptance rate maintenance, perhaps an output content increase also. However, this fact only partially could explain the notable increase in output content for just 43.39% of 53-MDPI journals received their first impact factor in 2017 or in 2018 while the increase in output content is observed for the all 53-MDPI journals.

Frequency of publication

The promotion of questionable special issues is one of the identifying characteristics of predatory journals (Alrawadieh 2020). Certainly, the number of special issues published or scheduled in 1 year reveals no quality-related information, although the fact that the number of special issues in JCR-indexed MDPI-journals is so much higher than the number of ordinary issues per year coupled with their constant increase since 2018 inevitably awakens suspicions of a lucrative business aim. As Siler (2020) stated 'since APC-based OA publishing involves remunerating publishers based on how many articles they publish, this can underpin perverse incentives to accept as many articles as possible to maximize revenue', so predatory journals 'operate in such a manner, eschewing legitimate peer review or other types of quality control' (p. 1386) and prompting an 'excessive publication of articles, often of inferior quality' (Siler 2020). On this point, the definitions of predatory journals of both COPE (2019) and Grudniewicz et al. (2019) highlighted the 'systematic for-profit publication' behaviour (COPE 2019) and its prioritization of 'self-interest at the expense of scholarship' (Grudniewicz et al. 2019). Both the increases in APC and the number of articles and special issues in JCR-indexed MDPI-journals may raise questions about the practices in use and their potential fit to these definitions.

Size of editorial board

The size of the editorial board is remarkably higher in all 53-MDPI journals analysed than in control leading journals. Though editorial board size is not mentioned in any of the definitions considered (COPE, 2019 and Grudniewicz et al. 2019), data show analysed journals have a completely different pattern in this matter when compared with leading journals in the category.

Peer review process

Peer review is a system of safeguards which, despite its limitations, fulfils its function reasonably well of ensuring that false research, of low quality, with serious flaws or inaccurate information is not disseminated, thereby avoiding misinformation (Elmore and Weston 2020; Siler 2020). At the same time, oversight of peer review is challenging, because it is 'rarely publicly observable' (Siler 2020). Predatory journals usually offer rapid peer-review processes, 'but without experts reviewing the quality of research and accuracy of the information' (Oerman et al. 2020). Peer review is used to 'evaluate the article for significance of the topic, relevance, rigor, analytic methods, conclusions, depth of discussion, and validity of conclusions based on data/arguments in the article' (Broome 2017), although predatory journals 'rarely invite experts who are experts in the field' (Broome 2017). From a prescriptive viewpoint, Teixeira da Silva and Dobránszki (2017) understood that the initial review could not 'reasonably' last longer than 1–2 months, to which another 1–2 months have to be added for subsequent revision of the paper, amounting to as many as 8 months, in the case of a process with three revisions.

As mentioned above, MDPI reports state that the median time from submission to publication for all its 218 journals was 39 days in 2019 (MDPI 2020) as it was in 2018 when MDPI published 203 journals (MDPI 2019). Comparable data from other publishing houses, which they rarely publish as aggregate figures, would be of interest, without which any comparison is impossible.

As an approximation and with the limitations that it might imply in general terms, that time can be evaluated by comparing it with the review metrics from Nature Research 2019 (https://www.nature.com/nature-research/about/journal-metrics), which show that the average number of days from submission to acceptance fluctuated between 81 days (Nature Structural and Molecular Biology) and 258 days (Nature Neuroscience). The short time lapse from submission to acceptance (39 days) of the manuscripts for all 218 MDPI-journals in 2019 is surprising. All the more so, if it is taken into account that, in addition, the editorial staff of MDPI is formed of researchers who have to organize their time for revision among their other professional activities (research, teaching, dissemination, evaluation, grant applications, etc.), rather than professional editors (as with the journals of Nature Research).

In turn, the publishing house Elsevier reported the average review and production times of its journals in such varied areas as Environmental Science, Computer Science, and Mathematics and Statistics (see Table 4). In concrete, great variability may be appreciated between the maximum and minimum review durations of its journals within different fields with regard to the speed of the review process, understood as the average duration from submission to the final editorial decision (including first decision-accept, reject or revise) (https://www.elsevier.com/physical-sciences-and-engineering/materials-science/journals/fast-publication).

Table 4. Elsevier's review speed (submission to final decision in days)

Field (number of journals)	Minimum (journal name)	Maximum (journal name)
Environmental Science[a] (41)	28.49 (Environmental Pollution)	211.12 (Weather and Climate Extremes)
Computer Science[b] (77)	13.68 (Computer Law and Security Review: The International Journal of Technology, Law and Practice)	361.83 (Computer Standards and Interfaces)
Mathematics and Statistics[c] (32)	11.13 (Applied Mathematics Letters)	232.05 (Applied Mathematical Modelling)
Material Science[d] (63)	18.62 (Nano Today)	141.61 (Cement and Concrete Composites)
Control and Signal Processing[e] (23)	24.15 (International Journal of Machine Tools and Manufacture)	198.1 (Mechanical Systems and Signal Processing)
Mechanical Engineering[f] (36)	41.58 (Case Studies in Thermal Engineering)	324.45 (International Journal of Pressure Vessels and Piping)
Process and Industrial Engineering[g] (8)	26.39 (International Journal of Engineering Science)	104.51 (Journal of Chemical Health and Safety)
Physics[h] (11)	2.59 (Physics of Life Reviews)	142.17 (Journal of Computational Physics)
Agricultural Science[i] (22)	37.52 (Field Crops Research)	184.87 (Global Food Security)

[a] https://www.elsevier.com/physical-sciences-and-engineering/environmental-science/journals/fast-publication-in-environmental-science.
[b] https://www.elsevier.com/physical-sciences-and-engineering/computer-science/journals/fast-publication.
[c] https://www.elsevier.com/physical-sciences-and-engineering/mathematics/journals/fast-publication.
[d] https://www.elsevier.com/physical-sciences-and-engineering/materials-science/journals/fast-publication.
[e] https://www.elsevier.com/physical-sciences-and-engineering/engineering/journals/fast-publication-in-control-and-signal-processing.
[f] https://www.elsevier.com/physical-sciences-and-engineering/engineering/journals/fast-publication-in-mechanical-engineering.
[g] https://www.elsevier.com/physical-sciences-and-engineering/engineering/journals/fast-publication-in-process-and-industrial-engineering.
[h] https://www.elsevier.com/physical-sciences-and-engineering/physics-and-astronomy/journals/fast-publication-in-physics.
[i] https://www.elsevier.com/life-sciences/agricultural-and-biological-sciences/journals/fast-publication-in-agricultural-science.

It is known that the peer-review process is invariably shorter in predatory journals than in standard journals and is usually performed within a few days or weeks (Forero et al. 2018). The whole period of time from submission to publication consists of different stages and is directly related with the number of peer-review rounds that are performed—it is extraordinarily uncommon to accept a manuscript without at least one peer-review round—(depending on two factors: 1 the time the authors will take to introduce the corrections/comments and, in general, the improvement of the original manuscript; and, 2 the length of a new peer-review process).

The didactic explanation of Broome was as follows:

> The speed to publication for reputable journals is certainly longer with time from submission to first decision by the editor ranging from 4 to 12 weeks for most journals and varies even by article. The speed to publication is dependent on several things, but primarily on how many reviewers accept an editor's invitation to review, how many of those who do accept actually complete a review, and how quickly the editor can make a decision based on their own read of the article and the reviewers' comments. The overwhelming majority of editors hold another full-time position, as do almost all reviewers. In addition, it is highly unusual to have an article accepted without revisions. So, the total time to print publication can be 6–8 months by the time the authors revise the article and the editor and reviewers decide if the revisions are acceptable. Once accepted, time to posting the final word document online on a reputable journal's Web site i.e. before print) varies but is usually accomplished within 2 weeks (Broome 2017).

The results showed the average time from submission to first decision of JCR-indexed MDPI-journals was 19 days, according to data provided in journals pages, section named Journal Statistics. The increase in the number of journals and articles published had no effect on time from submission to first decision. More specifically, 84.9% of analysed journals stated that they provided a first decision within <19 days. Although highly variable between journals, Teixeira da Silva and Dobránszki (2017) found no great variation between science, technology, engineering and medicine publishers: '3-4 weeks for peer review means about 6 weeks until to the first editorial decision' (Teixeira da Silva and Dobránszki 2017).

Elsevier provided a framework to assess time from submission to first decision in relative terms (Table 5). Once again, days from submission to first decision varied greatly, even within the same research field in Elsevier journals, while the MDPI-journals under analysis presented much greater homogeneity and, even, less difference between the maximum and the minimum times, which is to say the lowest intervals.

As the above results show, the review periods for all JCR-indexed MDPI-journals are similar and are commonly shorter than considered normal, despite the variation in number of published articles and themes. Further research would be needed to understand how these faster times are achieved.

Journal Impact Factor and self-citations

The analysis of journal self-citations is relevant (see Table 2), because the increase in the numerator of the Journal Impact Factor[4] boosts it and may be a stratagem to improve the position of a journal in the ranking through coercive citations, online queuing and self-cited editorials (Martin 2016; Wilhite et al. 2019), which clearly manipulate the metrics.

Another more sophisticated ruse (along the same lines, although less obvious) consists of collaboration between two or several journals to all cite each other in what have been dubbed citation cartels (Chorus and Waltman 2016). The Editor Ethics 2.0 Code (https://editorethics.uncc.edu/editor-ethics-2-0-code/) sets out an explicit ban on this malpractice in the fields of Industrial/Organizational Psychology and Management. Mutual citations between journals has led Clarivate to suppress several titles from JCR each year for

Table 5. Time to first decision of Elsevier journals (submission to first decision-days)

Field (number of journals)	Minimum (journal name)	Maximum (journal name)
Environmental Science[a] (41)	16.1 (Environment International)	147.35 (Weather and Climate Extremes)
Computers Science[b] (77)	8.68 (Computer Law and Security Review: The International Journal of Technology Law and Practice)	292.39 (Computer Standards and Interfaces)
Mathematics and Statistics[c] (32)	9.1 (Applied Mathematics Letters)	196.56 (Applied Mathematics and Computation)
Material Science[d] (63)	10.85 (Ceramics International)	123.48 (International Journal of Mineral Processing)
Control and Signal Processing[e] (23)	18.97 (International Journal of Machine Tools and Manufacture)	118.16 (International Journal of Industrial Ergonomics)
Mechanical Engineering[f] (36)	29.96 (Case Studies in Thermal Engineering)	271.53 (International Journal of Pressure Vessels and Piping)
Process and Industrial Engineering[g] (8)	23.03 (International Journal of Engineering Science)	64.12 (Computers and Chemical Engineering)
Physics[h] (11)	2.59 (Physics of Life Reviews)	92.54 (Journal of Computational Physics)
Agricultural Science[i] (22)	25.76 (Field Crops Research)	100.59 (Catena)

[a] https://www.elsevier.com/physical-sciences-and-engineering/environmental-science/journals/fast-publication-in-environmental-science.
[b] https://www.elsevier.com/physical-sciences-and-engineering/computer-science/journals/fast-publication.
[c] https://www.elsevier.com/physical-sciences-and-engineering/mathematics/journals/fast-publication.
[d] https://www.elsevier.com/physical-sciences-and-engineering/materials-science/journals/fast-publication.
[e] https://www.elsevier.com/physical-sciences-and-engineering/engineering/journals/fast-publication-in-control-and-signal-processing.
[f] https://www.elsevier.com/physical-sciences-and-engineering/engineering/journals/fast-publication-in-mechanical-engineering.
[g] https://www.elsevier.com/physical-sciences-and-engineering/engineering/journals/fast-publication-in-process-and-industrial-engineering.
[h] https://www.elsevier.com/physical-sciences-and-engineering/physics-and-astronomy/journals/fast-publication-in-physics.
[i] https://www.elsevier.com/life-sciences/agricultural-and-biological-sciences/journals/fast-publication-in-agricultural-science.

'citation stacking' (see, e.g. Journals Suppressed from 2018 JCR Data—2019 release—in https://help.incites.clarivate.com/incitesLiveJCR/JCRGroup/titleSuppressions.html), which as a consequence, will receive no impact factor for 1 year, due to the distortion of the rank of the journal in each category that no longer 'accurately' reflects 'the journal's true participation, by way of citation, in the scholarly literature of its subject' (https://support.clarivate.com/ScientificandAcademicResearch/s/article/Journal-Citation-Reports-Explanation-of-Missing-Dropped-or-Suppressed-Journals?language=en_US).

Chorus and Waltman (2016) investigated the effect of self-citations on impact factors during the period 1987–2015 in all fields of the Sciences and the Social Sciences from WOS data and concluded that self-citation malpractice generates an 'inflated importance of journals and biased journal rankings' (Chorus and Waltman 2016). Similar pernicious effects can be expected from citation stacking when journals cite each other to raise their impact factors (Heneberg 2016).

The results serve to point out how self-citation rates and intra-MPDI citation rates both followed a rise between 2018 and 2019. Both, self-citation and intra-MDPI citation rates directly affects the numerator in the journal impact-factor calculation, raising the journal impact value.

Conclusions

While there may be easily recognizable predatory journals, others have crept into prestigious databases such as Scopus (Cortegiani et al. 2020b), PubMed (Manca et al. 2018), MEDLINE, or Embase (Hayden 2020) with the appearance of legitimate scientific journals. Many of the studies on predatory journals in different scientific fields have been completed in reference to the journals listed on Beall's list, since discontinued (Shen and Bjork 2015; Frandsen 2017; Demir 2018; Alrawadieh 2020; Downes 2020). However, to the best of the author's knowledge, the study of a publisher such as MDPI has not been approached, except for very specific research on one of the MDPI-journals, Sustainability, in relation to self-citations (Copiello 2019) and its APC (Khoo 2019).

This investigation has approached the study of MDPI-journals that are ranked in the 2019 edition of JCR. Even though, on the one hand, the Journal Impact Factor is qualified by Ioannidis and Thombs (2019) as 'the most widely used, misused and abused bibliometric index in academic science', it is, on the other hand, a widely used tool for curricula evaluation and for making grant awards, as well as being used as a selection criterion for the dissemination of scientific results. Incorporation on the WOS and having a Journal Impact Factor provides a veneer of quality to the journal that extends to the authors that publish in it. It is therefore important to assess how each journal achieves the ranking that is published by Clarivate each year as a Journal Impact Factor.

The results presented above showed that the 53 MDPI-journals under analysis possess, to a greater or lesser degree, some of the criteria from various definitions for the identification of predatory journals and may deviate from best editorial and publication practices when e.g. mimicking names. The COPE/DOAJ/OASPA/WAME *Principles for Transparency and Best Practices in Scholarly Publishing* stipulate that journal names should not be easily confused with another journal and that journal websites should not guarantee very short peer-review times (as a member of COPE and DOAJ, MDPI could hardly argue that it ignores those *Principles*). Additionally, the constant and quite exceptional increase in the number of articles published in MDPI-journals between 2018 and 2019, reinforced by an exponential increase in the number of special issues, which easily outweigh the number of regular publications

(above all in view of the previsions for 2020), together with an increase in APC fees could bring into question the status of MDPI as a publisher, at the very least because its 'APC-based business model alters the economic and scientific incentives in academic publishing' (Siler 2020).

It is well known that the direct relation between income and the number of manuscripts that are accepted prompts predatory journals to conduct cursory peer reviews, in such a way that the rejection rate is minimal, so that ample economic returns are still guaranteed (Beall, 2016; Frandsen, 2017). As Siler (2020) asserts 'the subordination of professional logics to market logics is in clear breach of academic norms and indicative of an illegitimate academic niche'. The revision times of the 53 journals under analysis were surprisingly similar, regardless of the high variability of the articles published in each journal in 2019 and were, in many cases, very much shorter than time spans that may be considered normal. As such the question arises whether or not this speed is achieved with a thorough peer review in line with editorial and publishing best practices or if the rigor and quality of the peer review process is compromised in order to achieve these speeds. It is beyond the scope of this research to answer that question based on the analysis conducted, further research is needed to address this key question.

Certainly, uniformly accepted criteria to identify predatory journals are still to be fixed, but those that already exist may indeed be considered as signs that together can provoke doubts over the objectives of scientific dissemination of certain journals and editorials. Lending attention to these signs forms part of step 1 proposed by Kratochvíl et al. (2020) in the complex evaluation of a journal, to which another two must be added: 'combining objectively verifiable criteria with analysis of a journal's content and knowledge of the journals background' (p.1). These formal criteria, such as unambiguous determination of APC and Publisher, accurate information on the journal metrics, the inclusion of the name of the editor-in-chief, etc. are all necessary, although not sufficient conditions for proper identification of a predatory journal.

Having completed the verification of the formal criteria, Kratochvíl et al. (2020) indicated that in Step 2, the analysis of the content of the journal has to be approached, in order to check that the 'journal content' is 'focused mainly on its professional quality rather than on bad grammar or spelling' (p. 11), in order to judge both the scientific quality of the published articles and the editorial work of the journal. Logically, this step requires expert knowledge in each scientific field that prevents a global analysis of the 53 journals under analysis. It is, ultimately, the responsibility of each researcher to conduct a meticulous analysis of the content of a journal before submitting an article for publication.

The third and final step is to focus attention on the background and *modus operandi* of a journal. This step is greatly facilitated when a journal operates with open peer review. However, if otherwise, it is necessary to turn to other sources, such as the JCR and the Scopus index and to ascertain whether they have been excluded at any time from those databases (Kratochvíl et al. 2020). In the case of the journal having been included in JCR, the analysis of 'non-standard citation practices of the journal (a significant increase or fall in the number of citations, self-citations, and articles and majority of citations form a small group of journals)' is of great relevance (Kratochvíl et al. 2020).

Borrowing Martin's (2016) terminology, self-citation and citation cartels are stratagems that may be applied to attempt to boost a Journal Impact Factor artificially. In Falagas and Alexious's (2008) words, it 'is not only potentially insulting to the authors, but may also cancel the original meaning and value of references in scientific writing [. . .] and distort the true ranking of the journal in the scientific literature' (p. 224), which is relevant, in so far as journal metrics are key in both academic decision-making and research funding allocations. In fact, high impact factors may merely be due to citation cartels instead of true and legitimate scientific interest (Ioannidis and Thombs 2019). Self-citation and citation cartels deviate from best editorial and publication practices by breaking with publication ethics and integrity, which are defining characteristics of predatory journals according to Grudniewicz et al. (2019) and COPE (2019).

Specifically, with regard to the previously mentioned third step, the analysis of the background of the 53 MDPI-journals in JCR showed drops in their impact factors when excluding self-citations, which could be significant if the level of self-citations exceeded those of the leading journals in those categories in which they are indexed. Furthermore, no less importantly, the analysis showed that a large number of the citations that they receive are from other MDPI-journals.

As addressed in the discussion further work is necessary to understand whether these differences are meaningful and whether they persist when compared to a larger and more representative sample of journals in their respective subject areas.

Despite the fact that impact-factor manipulation may result in criminal liability according to Fong et al. (2020), the effect of self-citation and citation cartels may be halted by the use of JIF-without self-cites metric, a simple action that 'reduces the penalty faced by journals that decide not to manipulate so', in sum, 'ethical editors are not penalized and manipulative editors are not advantaged' (Wilhite et al. 2019). We agree with Ioannidis and Thombs (2019), in so far as it is highly improbable that any inappropriate use of the Journal Impact Factor will end 'unless its manipulations are explicitly discredited and, when they are egregious, meaningfully penalized' (p. 2). Only in that way will the editors' decisions be based on editorial reasoning rather than any covert intention to inflate citations artificially.

We therefore underline that JCR 'cannot be used as a whitelist of journals that comply with the criteria of transparency and best practice in scholarly publishing' (Kratochvíl, Plch and Koriťáková 2019), but rather as a tool with which to verify whether the background of a journal is adjusted to the best editorial publication practices. This is an especially important aspect when the external appearance of the predatory journals, such as the OMICS journals, has reached such a level of sophistication that they totally or partially comply with the formal criteria that serve to differentiate between predatory and legitimate journals. For example, they no longer have webs with typographic errors, but with a much more sophisticated appearance, converting themselves into a non-evident/hidden predatory publisher, in view of their editorial behaviour.

These results showed that the MDPI journals under analysis fitted some features of the definition of predatory journals (Grudniewicz et al. 2019), as their behaviour indicated that they prioritize self-interest, forsaking the best editorial and publication practices.

Implications

It is important that academia and scholars become aware both of the risks of falling into the networks of predatory journals and, in

addition, academics should be capable of properly identifying these journals, without presupposing that their inclusion in a prestigious database is a sort of quality hallmark that guarantees the integrity of their authorship, and both their peer-review and their editing processes (Severin and Low 2019; Cortegiani et al. 2020).

One form of avoiding the proliferation of predatory journals based on the gold open-access model, which can favour quantity over quality, would be to promote a platinum/diamond open-access model, in which neither the authors nor the readers pay for access to the articles and the costs of the publication process are met by associations or institutions (e.g. Universities, professional associations, ...). A platinum/diamond open-access model might be close to an ideal academic publishing model—according to the terminology of Siler (2020)—since it prioritizes professional rather than market logics and then eliminates the drive to publish as many articles as possible to maximize revenue. However, this solution could only work in the medium to long term.

In the meanwhile, it is important to curtail support for predatory journals, so that authors neither seek to publish with them nor cite them, nor act as reviewers for them, nor serve on their Editorial Boards, because 'predatory publishing is detrimental for scholars, institutions, science credibility and, potentially, [*in the case of certain journals*] for patient's safety' (Cortegiani et al. 2020) [italics added].

As a consequence of the new context generated by the proliferation of predatory journals, it becomes necessary to review the evaluation policies (Beall 2016). Thus, universities, funding institutions, or any institution that evaluates scientific activity can disincentivize the submission of manuscripts to predatory journals and the acceptance of roles on their editorial committees, ignoring these milestones in the evaluation process of a *curriculum vitae* (Forero et al. 2018; Bond et al. 2019). These actions will send out a clear message to researchers to refuse to publish in and to support predatory journals.

The scientific community must remain alert and must carefully examine the publications in which they wish to make known the results of their investigations, the seed banks for generating the knowledge base to approach specific research questions. Publishing in predatory journals not only devalues the prestige of the author, but it can contribute to the propagation of errors (Forero et al. 2018) with all the consequences that may entail, not only at a scientific but at a social level.

In summary: 1 researchers should neither send papers for their publication, nor cite them, nor act as reviewers for them, nor form part of their editorial committees; 2 research institutions should inform researchers of the reality of predatory journals and their iniquitous consequences at an individual and general level; and, 3 evaluation agencies and committees should ignore the registers that refer to predatory journals. Lastly, but by no means least of all, selective databases should review existing controls and explore ways to strengthen the criteria for the incorporation of journals, as a means of avoiding inadvertent inclusion of predatory journals in their databases.

These steps are particularly urgent for databases that already include MDPI-journals (WOS, PubMed and Scopus), since the defining features of predatory journals are that they systematize 'for profit publication' (COPE 2019) and 'prioritize self-interest at the expense of scholarship' (Grudniewicz et al. 2019). JCR-indexed MDPI-journals betray both traits through a steady increase in number of their published articles (sometimes to several hundred in just one regular issue) and special issues. Besides, JCR-indexed MDPI-journals mimicking names and publicly claimed rapid publication is in direct breach of the COPE/DOAJ/OASPA/WAME *Principles for Transparency and Best Practices in Scholarly Publishing*. Furthermore, the low variability of timeframes for peer review regardless of the scope of the journal, the size of its editorial board and the volume of published articles all raise questions over the levels of quality assurance required from a legitimate journal/publisher. Finally, self-citation and intra-MDPI citation rates artificially increase the impact factors of JCR-indexed MDPI-journals that is quite clearly in breach of best practice and integrity in science.

Limitations and future research

It is necessary to point out that the conclusions of this work must be assessed in the light of its limitations that likewise offer opportunities for new research work. The limitations of the available resources have meant that the analysis has been restricted to the behaviour of MDPI-journals in JCR over 2 years, 2018 and 2019, as well as the information available for 2020 in January 2020. It would be of interest to enlarge the time span for the analysis of these journals and to observe their behavioural patterns with regard to their citation practices. Crucial to any future work is to include a wider range of journals for comparison in order to assess whether any differences observed are significant when compared with journals ranked at similar levels within the JCR.

Further research is needed to compare the JCR-indexed MPDI journals to similar journals in their respective fields in order to understand whether the level of self-citation is significantly different for MDPI published journals. Due to the breadth of MDPI journals assessed in this paper it was not possible to conduct in-depth work to compare each journal. As such a single proxy was used in the form of the non-MDPI leading journal. However, since these journals are all the top journals by Impact Factor in their respective subject categories it is not possible to know whether the differences observed between the two groups are meaningful, a wider sample is necessary to draw definitive conclusions.

With respect to the formal criterion of the composition of the Editorial Board, it has not been possible to evaluate whether all the members who form part of these boards are in fact aware of their roles, due to their very high numbers (16,223 individuals), which could be approached in future research. So, another aspect deserving further investigation are the impressive numbers of faculty staff on the Editorial Boards of MDPI-journals, above all if compared with the leading journals from each category.

The lack of content analysis is a limitation of this study and could be performed in future research with a random sample of articles published in JCR-indexed MDPI-journals in line with Step 2 proposed by Kratochvíl et al. (2020).

Finally, the intense proliferation of predatory journals has given rise to predatory/fake conferences, equally pernicious for academia, and the subject of warnings from COPE (2019), as 'predatory journals and conferences are two sides of the same coin' (Cortegiani et al. 2020). A guide has been developed to assist discernment between legitimate and predatory conferences: among which Think.Check.Attend. (https://thinkcheckattend.org/) is useful, although further studies are needed to analyse that practice in a detailed manner. In particular, the 400 or so conferences that MDPI sponsored in 2019 (MDPI 2020) should all be carefully scrutinized.

Notes

1. Cukier et al. (2020), e.g. analysed 93 checklists in a systematic review of checklists for identifying predatory journals from biomedical fields.
2. Level 1 corresponds to journals, which meet at least the following basic scientific criteria: external peer review, academic editorial board and international or national authorship (https://dbh.nsd.uib.no/publiseringskanaler/OmKriterier.action). The most prominent and prestigious journals in a scientific field are promoted to Level 2 (publishing ~20% of the literature in that field) (https://dbh.nsd.uib.no/publiseringskanaler/VedtakNiva2).
3. https://publicationethics.org/resources/guidelines-new/principles-transparency-and-best-practice-scholarly-publishing.
4. The journal impact factor is calculated as: $\frac{citations\,in\,year\,X\,to\,items\,published\,in\,year\,x-1\,and\,in\,year\,x-2}{number\,of\,citable\,items\,in\,year\,x-1\,and\,in\,year\,x-2}$.

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