“PREDATORY” JOURNALS: AN EVIDENCE-BASED APPROACH TO CHARACTERIZING THEM AND CONSIDERING WHERE RESEARCH OUGHT TO BE PUBLISHED

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PREFACE

Contributions of authors

I attest that I, Larissa Shamseer, am the primary author (first or co-first) of the three published research articles contained within this thesis. For each of these chapters, the contributions of all myself and all co-authors are described in Appendix 1 using the Contributor Roles Taxonomy (CRediT https://www.casrai.org/credit.html).

Statement of originality

I declare that the research presented in this thesis represents original scientific work carried out in fulfillment of my PhD program in the School of Epidemiology and Public Health at the University of Ottawa. I received input and guidance from my PhD supervisor, my co-supervisor, my committee members, coauthors, and acknowledged collaborators throughout this thesis. I confirm that I co-conceived of and co-executed all studies, as described in the "Contributions of Authors" section.

Statement of financial support

During the first four years of my studies (May 2013 – April 2017) I was supported in-part by an admissions scholarship from the University of Ottawa. In 2014, I received a Destination 2020 Award from the Faculty of Medicine at the University of Ottawa. In 2014, I was also awarded a one year student research stipend from Knowledge Translation Canada to support my research including training activities and purchase of software to facilitate my PhD. The research carried out in Chapters 2 and 4 were carried out, in part, as part of my employment with the Ottawa Hospital Research Institute.

Throughout my studies I have also been fortunate enough to attend, participate, and sometimes speak at conferences, symposia, meetings relevant to my studies. These activities were supported by the grants listed above and by my primary thesis supervisor, Dr. David Moher.

Approvals

No approvals were required to conduct the research described in this thesis.

Copyright

Disclosures

My spouse runs a scholarly peer review management company and as a result receives income from various academic and scientific societies and scholarly publishing houses.

From 2015 onwards I was an Associate Editor (unpaid) for BMC *Systematic Reviews*.

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I would like to convey my gratitude to those who supported me during my doctoral studies.

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I am also fortunate to have had one of the most brilliant and forward-thinking minds in research, Dr. Jeremy Grimshaw, as my co-supervisor. Over the 10 years that I have known Dr. Grimshaw he has proven to be one of the most effective mentors, teachers, and problem solvers in my academic career. I am appreciative of the time he has spent listening to me and providing guidance on research, academia, and life. I am also inspired by and thankful for his gracious and lighthearted approach to providing critical feedback on my research and academic activities.

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THESIS ABSTRACT

Seemingly unscrupulous entities, referred to as "predatory" journals, have appeared in scholarly publishing over the past decade. Predatory journals have been characterized as using questionable publishing practices and consequently, as publishing questionable research. At the outset of this thesis, such assertions were based on little evidence, making it difficult to understand how to identify a predatory journal and judge the extent of the potential problem they present. This thesis sought to: (1) determine how the apparent operations of predatory journals differ from their presumed legitimate counterparts; (2) to characterize the epidemiology and reporting of biomedical research published in predatory journals; and (3) to determine what, if any, guidance health research funders provide about selecting journals in which to publish funded research. Predatory journals appear to be distinct from presumed legitimate journals in several ways. For example, they lack descriptions of their editorial processes, ethical policies, and content preservation arrangements more often than presumed legitimate journals. Researchers, globally, have published clinical and preclinical studies reporting on millions of research subjects in predatory journals. Such content is poorly reported against established reporting guidelines; some of it originates from high profile institutions and is supported by well-known biomedical research funders. Most major funders propose journal publication as one way of achieving open access, yet few provide guidance on how to select a journal for this purpose. These thesis findings suggest that some features encountered on journals' websites may signal potentially questionable journal practices. These features should be further evaluated to determine their accuracy in detecting predatory journals. Additionally, researchers may be sending research to predatory journals which may be of low quality, low priority, or unacceptable in legitimate journals. This is problematic because genuine research efforts/participant contributions may go undetected and never contribute to future knowledge generation. Future research ought to be done to determine why and how researchers, globally, choose where to publish. Research funders ought to agree on guidance and policies to ensure funded research can be found by others and is published in journals indicating basic standards for facilitating this.

Chapter 1: Thesis Background & Objectives

Note: Please refer to Box 1 (page 19) for a definition of terms used in this thesis

Scholarly publishing appears to be in the midst of a disruption in the form of "predatory" journals and publishers (1,2). Such entities are perceived as damaging both to science and to the scholarly publishing enterprise (3–6). Science and scholarly publishing are intimately intertwined. The scientific community relies on scholarly journals and publishers to disseminate its research, and the publishers relies on researchers' publications in order to remain in business. In 2018, the International Association of Scientific, Technical & Medical Publishers considered there to be 33,100 active English-language and 9,400 non-English language scientific journals in existence[1] (7). Biomedicine is the single-largest subject area within scientific publishing, comprising 30% of journals (7). The estimated revenue generated from English-language scientific journal publishing was $10 billion US in 2017 and $25.7 billion US if non-journal communication products (e.g., books, databases) are included (7). In turn, the academic community embedded within the scientific community also utilizes scholarly publishing as a mechanism for gauging the merit of research contributions. This introductory chapter presents what is known about predatory publishing, and its attendant implications for both legitimate publishing and for science which prompted the investigations in Chapters 2, 4, and 6.

At the outset of this thesis the extent to which predatory journals may be problematic was challenging to gauge due to the lack of empirical work about both what constitutes a predatory journal and what they publish. Additionally, it was unknown whether guidance or policies exist to guide researchers in their choice of journals. This thesis aims to provide empirical evidence to address these gaps in knowledge.

A publishing façade

"Predatory" publishing has been used to refer to a subset of scholarly publishing entities that outwardly appear as legitimate scholarly journals, but which do not carry out promised or practices expected of such journals (8,9) – a scholarly publishing façade, in effect. Predatory journals are also known to charge fees to authors (akin to article processing charges [APCs] present in many legitimate journals) for their purported services (10). A 2013 exposé in *Science* demonstrated an unusually high acceptance rate (68%) of a purposely and obviously flawed study among predatory journals (vs 38% at legitimate journals) (11). This brought predatory journals and their absent or minimal peer review into mainstream consciousness for the scientific and publishing communities (11). From there, many researchers, research organizations, librarians, and editorial organizations used (what was then) the only source of information about the

[1] Based on Ulrich's Periodical Directory; no indication of whether list contains journals thought to be "predatory".

phenomenon - a blog created by librarian Jeffrey Beall who offered some of the first definitions of predatory publishing and formally tracked the phenomenon between 2011 and 2017 (8,12).

Beall's List

Jeffrey Beall appears to have been the first to identify a distinct subset of journals and publishers claiming to be open access and collecting fees for publishing research but not carrying out practices expected of such journals in 2009 (13). He first used the term "predatory" to describe these in a 2010 review article (titled ""Predatory" Open Access Publishers") (8). In it, he rationalized that,

> *"these publishers are predatory because their mission is not to promote, preserve, and make available scholarship; instead, their mission is to exploit the author-pays, Open-Access model for their own profit." Jeffrey Beall, 2010 (8)*

Beall's initial characterisation of predatory journals has largely framed and permeated our basic understanding of predatory journals. His blog, initiated in 2010, entitled "Scholarly Open Access", documented numerous examples of the non-standard ways he perceived these journals and publishers to look and operate. The blog's main content were two freely available, well-known lists of Beall-designated "potential, probable or possible predatory scholarly open access" publishers (i.e., overseeing more than one journal) and journals (i.e., those independent from a fleet of publisher journals). Collectively, these lists have come to be known as "Beall's List". In the time that he tracked them, the numbers of predatory publishers and journals on his lists grew exponentially, averaging annual increases of 187% and 82%, respectively[2]. Since Beall ceased updating his lists and hosting his blog in January 2017, replacement lists have arisen, such as the subscription list by Cabell's International (14) as well as other freely accessible lists built off of Beall's original listings (15,16). Additionally, alternate/improved definitions have since appeared, some building on accumulating evidence and characterisations of the phenomenon (17–20). However, none have yet achieved similar popularity or reputation among the scientific community. Such was the influence of Beall that his eponymous list remains the 'go-to' listing of predatory publishing entities, possibly because it relieves others' the burden of having to consider the nuances of definitions.

Though Beall's efforts were important in alerting the scientific community to a potential problem in publishing, his approach to defining predatory journals and publishers has been criticized as imprecise and irreplicable (21–25). To designate entities as predatory, Beall devised criteria that he published alongside his lists, which evolved over time. His third and last documented criteria in

[2] Based on the last formal counts provided on Beall's blog, found at: https://web.archive.org/web/20170103170903/https://scholarlyoa.com/

2015 consisted of 56 items which he indicated were informed by the Codes of Conduct put forth by the Open Access Scholarly Publishers Association, Committee on Publication Ethics (COPE), and International Association of STM Publishers (26). If some (unclear how many) items were present to some degree in journals he encountered, he took this as a signal that a journal or publisher was predatory and added it to his list. He was the sole adjudicator and did not indicate which criteria each journal or publisher on his list met/did not meet (22,27). Consequently, well-intentioned journals and publishers sometimes appeared on Beall's List (28), and critics claim that entities with less pure intents may have gone undetected (27). One comment posted to the *Scholarly Kitchen*[3] reflects an utter frustration with Beall's failure to distinguish predatory from non-predatory journals, "Jeffrey[…] your concept of predatory is hopelessly confused. It is just whatever you do not like." (29). The uncertainty born out of Beall's non-transparent approach and how predatory journals could be detected or distinguished from legitimate journals prompted the investigation in Chapter 2.

Beall's conception of predatory publishing also appears to have been singular and unbending – journals are either predatory or not. The problem with this was neatly articulated in a *Scholarly Kitchen* post, "Beall's error is a common one, and that is to characterize a group by its most extreme elements." (30). Such a characterisation fails to acknowledge that a range of intentions and apparent practices, from malfeasance to low competence, may exist within what Beall designated as 'predatory' (31,32). The following section describes two potential ends of the predatory spectrum that appear to have been be captured in Beall's 'predatory' definition.

The predatory spectrum

At one end of the predatory spectrum are journals whose practices appear clearly unethical. However, whether their intent is unethical or truly misguided is unknown. For example, some journals designated as predatory reportedly appear to mimic the names, websites, and logos of legitimate journals (e.g., *British Journal of Medicine* vs *British Medical Journal*) – a likely attempt to confuse or deceive authors into publishing with them. Some predatory journals have also reportedly used the logos of, or claim to be indexed in, trusted scholarly databases (e.g. the Directory of Open Access Journals, DOAJ) (33), and have been found to dishonestly list academic researchers (real, fake, or deceased) on their editorial boards without consent (34,35). Such activities may be an attempt to convey credibility. Additionally, in an unknown number of extreme cases, predatory publishers have reportedly 'hijacked' legitimate journals (e.g., by redirecting traffic to a mock replica journal website or assuming control of accidentally lapsed domains) (36). At least two legitimate Canadian publishers have been bought by the presumed largest predatory publisher, *OMICS Publishing Group* (37). *OMICS* (founded in 2007 and running roughly 700 journals at the time of writing) was first brought to public attention through Jeffrey Beall's blog. Its founder, Srinubabu Gedela, has indicated that his experience trying to track down research behind paywalls

[3] a well-known blog among the publishing community from the Society for Scholarly Publishing: https://scholarlykitchen.sspnet.org/

for his PhD (which he describes as having to take an overnight bus to libraries in the large cities once per month to obtain access to content he needed) prompted him to start a freely accessible scholarly publishing company for people in his country and for others in similar situations, globally (38). Ostensibly, his motivations sound similar to those who pioneered and advocate for open access publishing – to make the "treasury of scientific information available to a much wider audience" (39). His implementation of open access and attaining publishing standards, however, has been problematic for both the scientific and publishing communities. In 2019 the US Federal Trade Commission (FTC) levied a $50 million fine against *OMICS* for the use of "deceptive" claims about the nature of their journal operations[4] (a fact first called to attention in Jeffrey Beall's blog) (40). These include claiming to offer rigourous peer review (despite contrary evidence), failing to disclose publishing fees at the time of submission, listing prominent academics on editorial boards (without their agreement to be affiliated with the journal), and claiming to be accepted in prominent indexing services (when journals were largely not) (40). Subsequent attempts by *OMICS* to implement widespread publishing practices appear to have been thwarted by legitimate publishing organizations. Following the FTC ruling in April 2019, Crossref, a not-for-profit company that allocates digital object identifiers (DOIs) to scholarly publishers revoked *OMICS'* paid membership and stopped issuing DOIs for its articles (41). One publishing industry insider has flagged that *OMICS'* may have since started making up DOI's (i.e., fake DOI's) to accompany published articles (42). This will obviously not fulfill the purpose of a DOI, which is to ensure discovery and permanent identification of published content (43), and may instead deceive authors into thinking *OMICS* is utilizing standard publishing practices.

The unethical nature of some predatory journals and the FTC ruling against *OMICS* confirms that some journals that have been designated as predatory are indeed problematic. However, this example also raises questions about who the arbiter of legitimate journal practices is. For instance, who is or should be policing the ethics of journal practices?[5] Does Crossref's decision to ban *OMICS* following the FTC ruling make its membership a marker of journal legitimacy? And how will potentially trustworthy research published in *OMICS* journals be discovered going forward without genuine DOIs (or indexing)? Predatory publishing has provoked questions about the ethics of and adjudication of ethical practices in scholarly publishing.

Though the above narrative and example fits the description Beall commonly used to describe predatory journals, it is confounded by the appearance on his list of what may have been legitimate journals with poorly produced publishing efforts that may have shared similar traits with intentionally deceptive journals. One such group, for example, may be local journals based in lower income countries or in non-prestigious colleges and universities. On the last-posted version of Beall's alphabetically listed journals, the first that appears to be based out of a specific institution is the *Al Ameen Journal of Medical Sciences.* The journal is the official publication of the Al Ameen Medical College – an institution recognized by the Medical Council of India. Such journals may

[4] OMICS' deceptive marketing for predatory conferences was also recognized as a distinct problem by the FTC; further discussion of these are not warranted here given the context of this thesis is scholarly publishing

[5] While COPE provide guidance on journal ethics, they have no monitoring capacity or regulatory authority

strive to operate and appear legitimately but may have little funding to support their operations such as to employ individuals versed in standard or ethical journal practices (set by prominent publishers/organizations coincidentally based in higher income countries). Additionally, such journals may not have the funds to pay for services used by legitimate journals such as professional website designers, publishing consultants to help form/implement journal policies (e.g., processes for corrections, retractions), plagiarism detection software, peer review management, article production, digital object identifiers assignment, or negotiation with databases/indexing/ journal ranking services (44). In the absence of such services, some journals may evoke a sense that they are little more than rudimentary endeavours. Their editorial, ethical, and peer review policies may seem under-developed in comparison with established journals. It also remains unclear how rigorously their policies, such as they are, are managed. As a result, the likelihood of such journals meeting the criteria for acceptance stipulated by various indexing bodies is low, while simultaneously having a high potential of being included on Beall's List.

Beall's efforts first raised awareness among the scientific and publishing communities about a previously unknown and growing subset of journals using potentially questionable practices. However, the lack of evidence/use of evidence to inform his increasingly prominent listing of predatory journals. Potentially compounding these issues were Beall's personal opinions and preferences about scholarly publishing overall which tended to accompany the information he provided about predatory publishing. In interviews he gave (45) or commentaries he authored (sometimes in influential journals (3,46)), he showed unfiltered disdain for author-paid open access publishing (47), non-English language journals[6], and a preference for subscription publishing (47,48)[7]. Due to his influence as a public figure (49), Beall's personal opinions (and potential misconceptions) of publishing may have biased residual perceptions of what constitutes predatory publishing. Nonetheless, the impacts of predatory publishing on the scientific and publishing communities remain important.

What prompted predatory publishing and why has it sustained?

Questionable journals and publishers seem to have emerged into the scientific publishing landscape in growing numbers over the past decade and have sustained, if not thrived. This section describes what may have prompted this situation and enables its continuity.

[6] Beall once referred to SciELO, the widely used Brazilian-based Open Access publishing platform and database for IbericoAmerican and other non-English research, as a "publication favela" (29).

[7] Beall once described open access as an attempt to "kill off for-profit publishers" (48)

Digitalization of legitimate publishing provided fertile ground for predatory publishing

The introduction of the Internet enabled scholarly publishing to be digitalized (50). This both solved and introduced challenges in publishing. Most immediately, it enabled journal content to be delivered to readers electronically via the internet thus reducing the costs associated with printing and physical distribution[8]. It also permitted journal operations to be managed virtually[9]. While this has improved the efficiency of publishing, it has also allowed anyone with an internet connection to provide publishing services (or purport to).

Digitalization presented the opportunity for a new publishing model – one that enabled free access to digital content with revenues collected from sources other than subscriptions. A precedent for such a model was first set by the publisher *BioMed Central (BMC)*, the first large-scale open access publisher (launched in 2000), which first introduced author-side payments (i.e., APCs) as a way of funding publishing activities (51). Vitec Tracz, its founder, describes his initial gamble on APCs as based on authors' pre-existing willingness to pay for page and colour charges in subscription journals[10] (51).

> *"After all, it's the legitimate job of commercial publishers to make profits, and I see myself as one of them" – Vitek Tracz, founder of BMC, 2005*(51)

The factors facilitating digitalization and open access publishing may have paved way for the exploitation of scholarly publishing by unscrupulous parties. Such factors include: the normalcy of APCs resulting from *BMC's* and others' success (e.g., *Public Library of Science*), particularly in biomedicine (52); the possibility of virtual journal management; and importantly, the underlying reliance and trust that researchers have in scholarly publishing (i.e., that publishers/journals will deliver on their promises).

Financial support for APCs

Predatory journals and publishers continue to exist because it is profitable for them to do so. There is also little regulation to counter their existence. Those funding publication charges in predatory journals, potentially including research funders and academic institutions, are indirectly contributing to sustaining their operations (53). Additionally, investments in research overall are likely to be wasted if findings are published in predatory journals since their discoverability by others is limited (see scientific integrity). In biomedicine, researchers indicate that grant funding

[8] many journals still also produce print versions

[9] See 'Disclosures' section of Thesis: my spouse runs a virtual peer review management for scholarly journals

[10] Publication-associated fees in subscription journals have been condemned as "hidden charges" for not always being apparent to authors at the time of submission (175).

is the primary source of support used to pay APCs (54). Thus, the unfettered and unmonitored provision of research funds to pay such charges may be problematic. Research funders are not only positioned to monitor researchers' publishing activity/behaviour, but to also guide it through recommendations and policies (such as open access mandates) when allocating funding. In Chapter 6, recommendations and policies of health research funders regarding journal selection are assessed.

The academic incentive

For researchers, selecting a journal in which to publish is a specific behaviour. Behaviour has been proposed to be the result of an individual's capability, opportunity, and motivation to act, with motivation outweighing the two former characteristics (55). Publication-based productivity is the prevailing mechanism for measuring scientists performance and allocating rewards (i.e., career advancement, funding) in academic science, globally (56,57), with few exceptions (58). Dominant measures of productivity include the number of publications, citations, ranking of publishing journals, authorship order, and the number of grants a researcher accrues (57). Academic reward dependent on the quantity or outlets of publications has been characterised as problematic due to its potential to motivate compromised publishing behaviour in order to secure a competitive advantage (59). For instance, it may incentivize researchers to conserve their research efforts to produce studies of low rigour/importance for submission to willing journals (i.e., least publishable unit) (59) or to divide findings from a single study into multiple publications (i.e., 'salami slicing') without acknowledgement in order to appear more productive (59). Stanford epidemiologist John Ioannidis contends that academic research is often "conducted for no other reason than to give physicians and researchers qualifications for promotion or tenure" (60). Mark Neff, an environmental scientist, takes this one step further proposing that academic science has given its "soul to the publishing industry" (61). Potentially compounding the problem is that governments and third-party organizations measure institutional productivity to determine their rank and overall worthiness of future funding against other institutions nationally and globally (62).

In 2005, Vitek Tracz remarked that "authors are more interested in publishing than readers are in reading" (51). Like legitimate publishers, predatory journals may be benefitting from academic rewards based on publications. Research that is deemed unacceptable (by researcher or editors) in legitimate journals may be sent to predatory journals in order to secure a publication (63). While some researchers may knowingly submit to such journals, others may be attracted to the promise of rapid publication at such journals without care for or knowledge of norms or standards in publishing practices. Problematically, predatory journals appear to operate in the space between potentially naïve academic scientists who are incentivized to publish and a publishing landscape in which the hallmarks of legitimacy seem to be unclear.

Another consequence of publication-based academic reward is the demand it creates on a limited supply of scholarly journals. In India, for example, a distinct academic reward system has been blamed for giving rise to many predatory journals as well as incentivizing authors to publish in them (64). In 2010, the University Grants Commission (UGC), the nation's higher education regulator, introduced Academic Performance Indicators (API), which set minimum numbers of

required publications PhD student and faculty must achieve in order to progress academically (65). Higher API scores are awarded for publishing in international and foreign journals than national or local journals (66,67). While in 2014, India had the distinction of being among the top contributors in legitimate scholarly publishing (ranked 13th in the 2014 *Nature Index*) (68), in 2013, it was also the most represented country by author for publications in predatory journals, accounting for a 35% share of the global distribution (69). It was also detected to have the highest global concentration of predatory journals in the world (27% in India, 18% in North America, 12% in the rest of Asia, 9% in Europe, and 6% in Africa, and the rest were elsewhere) (69). UGC's academic evaluation policies have since been blamed for incentivizing predatory publishing to proliferate.

There appear to be specific aspects of UGC's policy that may have prompted and worsened the rise of predatory journals in India; two examples are highlighted below:

1) ***Unqualified faculty are expected to produce research publications***: A feature of UGC's policies is that the expectation to publish a minimum number of papers applies to faculty across all UGC higher education institutions - including for teaching-focused faculty or facilities (70). While no studies appear to exist investigating the association between teaching and research faculty/facilities and predatory journals, it would not be surprising if faculty at these institutions were submitting fake or subpar research (which they are unskilled to carry out) for publication in purported 'international' predatory journals in order to be eligible for promotion. To combat predatory publication, UGC has introduced measures to facilitate collaboration between teaching and research faculty and institutions and has produced lists of acceptable journals in which trainees and faculty are permitted to publish to be eligible for career advancement (71). The basic requirement for all faculty to publish, however, still exists, largely unchanged from 2010 (72). It has been suggested that teaching-focused faculty or faculty at new institutions elsewhere in the world may be similarly driven to publish in low-barrier journals or predatory journals given their limited time to produce research and, potentially limited skills to conduct rigourous research considered acceptable by legitimate journals (73).
2) ***An 'international' publishing requirement:*** By allocating greater rewards for publishing in international journals, the policy positions local, India-based journals as insufficient and irrelevant for researchers to publish in (64,71). Legitimate journals with international reputations are known to publish proportionally less research authored by researchers from lower income countries, despite the concentration of researchers from such countries being greater (66,67). This has created an opportunity for journals branding themselves as 'international', 'global', 'American' or from elsewhere, which unsuspectingly do not carry out modern publishing operations, to attract researchers wanting to advance their careers (64). Researchers in other countries with similar 'international' publishing requirements/rewards are also overrepresented among authors in predatory journals (e.g., Nigeria (74–76)).

The dependence of academic career assessment/advancement on an industry (unregulated) built on trust leaves such evaluation open to abuse by researchers, and, in turn, researchers vulnerable to exploitation by journals/publishers. Some have suggested that researchers are purposely seeking out predatory journals in order to inflate their CVs for academic assessment with otherwise worthless publications (73). This has not yet been shown to be true, however, it is likely

a difficult phenomenon to study – researchers may be reluctant to confess to engaging in potentially unethical practices. There is evidence, however, that some researchers may turn to predatory journals due to frustration with the expectations and long delays (i.e., time in peer review and article production) associated with many legitimate journals (77–80).

Some systems of academic advancement also require researchers to publish in particular journals. Some countries even financially reward researchers for publishing high impact factor journals (81) or those indexed in Web of Science and Scopus (82,83). In Italy, the national system of academic evaluation for tenure and promotion rewards researchers for publishing in Scopus-indexed journals (84). An investigation into the CVs of assistant and associate professors being considered for tenure and promotion across Italy (46,244 total) found that about 5% of researchers had published in a journal on Beall's List (30% had more than one such publication) (84). Of note, such researchers also had less years of experience, published in lower impact legitimate journals, and published more prolifically than their counterparts without predatory publications. When surveyed, professors reported being motivated to publish in Scopus-indexed journal to advance their career (some predatory journals are either validly indexed in Scopus and others falsely claim to be (85)). Ninety percent of professors who had published in a predatory journal reported being unaware of its characterisation as such before submission. Some researchers report being appalled by their experience with the journal, *"I think that the journal should be shut down" and, "the editor in chief is a crook"* (84). Of the 10% of researchers who knowingly published in predatory journals, some indicated that they believed that the journal's inclusion in Scopus meant it would count towards their evaluations. The investigators of this study did not ask whether they thought a journal being indexed in Scopus conveyed legitimacy nor did they provide any indication of the quality of research sent to predatory journals. Available findings from this study suggest that the majority of academic researchers may earnestly be submitting research to predatory journals.

While not the focus of this thesis, understanding the relationship between academia and publishing is fundamental to understanding why predatory journals may exist/sustain and potentially why they appear and operate as they do.

Why should we care about predatory publishing?

Scholarly publishing functions on the basis of trust: trust in the intentions of authors, trust that peer reviewers and editors will regulate what reaches the body of literature for a given field, and trust that publishers will deliver on the current standards of metadata, content preservation, and dissemination through standard channels. That some journals may be exploiting this trust ought to concern both the research and publishing communities. Some researchers may be unable to distinguish predatory journals from legitimate journals as a result of deception or poorly produced publishing operations. Others may be driven to predatory journals because the current legitimate scholarly publishing landscape is not suitable or equitable for all, resulting in potentially trustworthy research being excluded from the identifiable scholarly record. Lastly, the public

ought to be concerned, given the potential widespread potential both for important research to go undiscovered and for misinformation to spread via predatory journals (86,87).

Deceptive journal practices confuse authors

Solicitations from predatory journals have filled the inboxes of academic researchers, inviting publications in fields sometimes unrelated to researchers' expertise and using flattering language, possibly in an attempt to attract novice authors craving recognition for their early scientific efforts (88,89). They have collected money for services that authors expect (or that they have even promoted)(40) but largely fail to provide (e.g., peer review) (11). Often authors are unaware of their publishing fees (APCs) at the time of submission due to the failure of some predatory journals to disclose them until research is accepted for publication (10). For some scientists, such as those with established publication records or those whose work is regularly accepted for publication in the top journals in their field, predatory journals represent a simple nuisance – an unwelcome incursion into their inbox to be deleted each morning. For others, perhaps less experienced with scholarly publishing (90), predatory journals have truly made the publishing landscape more difficult to navigate when trying to select a reputable journal in which to publish.

The scientific community has limited knowledge about scholarly publishing

Researchers publishing in predatory publishing reveals the scientific community's potential naivety in our expectations, assumptions, and understanding of scholarly publishing. The scientific community has co-existed with scholarly publishing for decades, albeit with seemingly little understanding of how publishers operate or are supposed to operate. The integrity researchers assume of legitimate journals is largely based on their faith that publishers and editors are acting honorably (91) or that peer review is functioning as intended (92). Researchers' expectations around publishing and how it should work, particularly peer review (which has been demonstrated as inadequate or absent among predatory journals (11)) have been described as emotion-based, rather than evidence-based (93,94). We trust that the largely confidential vetting of research through peer review is adding value despite repeatedly being shown its failures to detect problematic research (95,96). We expect that researchers will and should learn how to navigate scholarly publishing through experience, rather than providing formal training on publishing ethics and how to select journals based on credible practices (97). Further, researchers are often expected to commence publishing while still training, yet little formal curriculum seems to exist regarding publishing ethics and standards (97,98). The scientific community's faith-based and evidence-lite trust in scholarly publishing may have allowed predatory journals to permeate the publishing landscape unnoticed, particularly affecting researchers with little experience in legitimate publishing. Observers have reflected that science's faith in the utterly non-scientific system of scholarly publishing is somewhat laughable (99). This would be true if not for the potentially damaging implications for scientific publishing and for science overall (see section on 'scientific integrity').

Legitimate open access publishing may be conflated with predatory publishing

The reported presentation by many predatory journals as "open access" and their collection of publication fees from authors (8) has fueled and reignited existing uncertainties about legitimate, author-paid, open access publishing. Some with opinions about predatory journals have conflated them with their legitimate open access counterparts (48). Most notably in this camp, perhaps, is Jeffrey Beall. His use of the phrase "*Scholarly Open Access*" as the official title of his blog that tracked predatory publishing, potentially gave the impression that questionable activities are occurring across all of open access publishing. He also repeatedly referred to any fee-collecting journals (including legitimate APC-collecting open access journals) as 'predatory' in nature and has deemed the entire landscape of author-paid open access publishing to be corrupt (48).

The legitimate open access publishing model is predicated on providing free digital access to research and enabling its unrestricted re-use by others (in contrast to subscription publishing in which access to research is paid for and for which licensing is typically more restrictive) (100). Collecting fees from authors to generate revenues in open access publishing was pioneered by two now-prominent open access publishers launched in the early 2000's, *BioMed Central* (*BMC*) and the *Public Library of Science* (*PLoS*) (51). Their large-scale success and sustainability thus far has lent credibility to author-paid open access as a business model (101,102). An industry of legitimate open access publishers and journals (i.e., those offering immediate open access to all content, termed 'gold' open access) has flourished in their wake.

At the outset of author-paid open access publishing, opponents (which initially included long-standing subscription-based publishers (103,104)) claimed that the model was of intrinsically poor quality (105,106). Their concern being that the collection of fees to publish research incentivized publishers to prioritize quantity over quality. Some concluded that their high acceptance rates[11] and correspondingly high volume and speed of their published output (open access "megajournal" PLoS One published over 31,000 articles in 2013 (107)) meant that they could not possibly be carrying out the same level and rigour of peer review as subscription journals (108). Evidence has accumulated showing such criticisms are largely unjustified. Specifically, the quality of peer review reports, assessed, has not been shown to differ between open access journals and subscription-based journals (109,110). Additionally, some open access journals are among the top-ranked journals in the Science Citation Index (i.e., impact factor) (111) – a widely regarded measure of journal, and sometimes article, quality (112). This demonstrates potentially similar scientific impact of open access and subscription journals.

Many originally subscription-based publishers have adopted open access publishing. For instance, some now also produce author-paid open access journals, provide author-paid immediate open access within subscription journals (called 'hybrid' open access (113)), or enable access to

[11] estimated average acceptance rate of 46% across all open access biomedical journals compared to a 5-20% at top subscription biomedical journals (176,177)

subscription content after an embargo period (called 'delayed' open access (114))[12]. In 2017, *Elsevier*, among the oldest subscription-based publishers in existence, simultaneously became the largest subscription-based publisher, the second-largest publisher of open access journals, and the third-largest producer of open access articles (115). When large-scale open access first emerged in 2000, approximately 5% of published scientific articles were recorded as freely accessible via journal websites or in repositories. In 2017, 28% of articles were open access varying by specialty (e.g., >50% of articles in biomedicine were openly accessible)[13] (115).

That many predatory journals refer to themselves as "open access" and that they are difficult to distinguish from legitimate open access journals may undermine the work done to dismantle concerns around the quality of legitimate open access publishing. Conflation between legitimate and predatory 'open access' journals may be compounded by the influential[14] Bohannon study (11) comparing acceptance rates between legitimate and predatory 'open access' journals. The study concluded that many open access journals failed to detect the submitted falsified research, but it lacked comparison to legitimate subscription-based journals thus implicating problematic peer review as a feature of open access journals overall. Additionally, we still have little idea of how peer review at subscription-based journals performs under the same conditions compared to predatory journals. Others, such as Beall, have also conflated predatory and legitimate open access journals rather than distinguishing the former as being substantially worse at filtering out bad research. Predatory journals and some descriptions of them may reinforce pre-existing uncertainties about the quality of open access publishing.

Predatory journals are an indictment of legitimate publishing

Due to the relative ease with which predatory journals seem to be conflated with open access journals, predatory journals may have disrupted prevailing notions and expectations about the nature of scholarly publishing. Some in the publishing industry worry that predatory publishing is leaving a "black mark" on legitimate publishing that few observers will be able to parse (116). Others worry that the apparent lack of transparency, integrity, and rigour of operations at legitimate journals is sloppy and has truly contributed to researchers' confusions in selecting journals (117). As alluded to earlier predatory journals have revealed some weaknesses and prompted questions about the nature, ethics, and transparency of legitimate publishing practices. From this, several questions about legitimate publishing ought to be considered:

[12] Delayed open access publishing was prompted as a result of funders' open access policies. It typically comprises free access to research, rather than complete open access (i.e., restricted re-use) and publication fees may or may not be present (178,179)

[13] Estimate excludes articles made available through non-legal mechanisms such as academic social networks like ResearchGate

[14] The Bohannon study is the 16th-most shared article (via media, social media) published in *Science*, ever https://www.altmetric.com/details/1801320

- How can journals that look and operate so poorly be attracting submissions from researchers?
- Do poor practices and appearances equate to malicious intent?
- How can a publisher's/ journal's intent be determined?
- What is the line between a legitimate publisher/journal and one that is not?
- Is there a threshold of practice beyond which a journal or publisher should be considered predatory?
- Why has the legitimate publishing community failed to define for itself and for others what a scholarly journal is and minimum standards it should attain?
- Why have legitimate journals and publishers failed to provide universal signals of their transparency and credibility for researchers?

Predatory journals may benefit from structural inequities in legitimate publishing

The legitimate published literature appears be dominated by certain types of researchers (higher income, English-speaking), while others are underrepresented (lower income, non-native English speaking) (90,118–120). This phenomenon has been characterised as the 'centre' and 'periphery' of scholarship (99,121). Contributors to predatory journals have been characterised as being from lower income countries or as having fewer previous publications (i.e., less publishing experience) than authors who publish in legitimate journals (84,90). This suggests a disparity in who is participating in or, potentially, in who is able and allowed to participate in legitimate publishing. This is possibly due, in part, to the costs associated with accessing research in subscription journals (e.g. subscription charges) and of publishing research in many journals (e.g., open access fees or print-related charges). Payment to participate in publishing inherently fosters an inequitable scholarly publishing environment. Such systemic inequities may contribute to researchers' selection of predatory journals.

By their nature, subscription fees to access research prevent nonpaying parties from reading, and, consequently, from building on inaccessible research. As a result, researchers who (or those whose institutions) cannot afford the cost of subscriptions may be left out of the scholarly discourse – an activity involving both reading and publishing research. In turn, the research they produce may be of low interest to subscription journals[15]. Initiatives exist to facilitate free or low-cost access to subscription journals for researchers in low income countries. Research4Life is a collaboration between the World Health Organization and many subscription publishers. It provides low or no cost access to approximately 20,000 biomedical journals in 125 countries (selected based on a maximum total or per capita gross national income [GNI]). However, many highly populated

[15] Unaffordable subscription pricing for scholarly journals has been problematic in higher income countries as well. Since at least the 1980's research librarians worldwide have complained that increases in publisher's subscription prices outpace increases in library budgets (which are also sometimes stagnant or decreasing); this situation was declared as the 'serials crisis' in 1991 (180). In an unprecedented pace over the past five years, academic libraries worldwide have been canceling their contracts with large subscription publishers for more affordable options (181).

countries do not qualify for access due to transitioning economies or because their GNI is above the determined maximum, despite having large income inequalities within them (e.g., India, China, Mexico) (122,123). As a result, many researchers around the globe still cannot access paywalled research, which represents nearly three quarters of published research (115).

Open access publishing was initiated in part, to counter the inaccessibility of published research globally. At the time of writing, almost 15,000 gold open access journals exist[16] and, as of 2016, at least 10,000 subscription-based journals were estimated to provide hybrid open access (124). While most gold open access journals are free to publish in, those charging APCs (i.e. author-paid) are concentrated in biomedicine, and researchers tend to opt to publish in these (52,125). This may be because of their inclusion in trusted indices and high ranking/citations among top journals in their respective fields (125). While author-paid journals are popular in some disciplines, the affordability of APCs has been a long-standing criticism the publishing model (126). A 2014 survey of Canadian and US institutions found that the average APC charged for publishing a research article in a gold open access journal was $1864 USD and in a hybrid journal was $3000 USD (127). In comparison, the per capita GNI in India in 2014 was $5,170 USD[17]. Like their subscription-based counterparts, many author-paid open access publishers offer APC waivers or discounts to researchers in lower income countries (128,129). Also like subscription publisher discounts, however, these are inapplicable to many researchers who may need them (130). Even for researchers who are eligible to receive such benefits, the legitimate author-paid publishing model positions them as the exception rather than the norm, since only few such waivers can be afforded in order to maintain publisher revenues (131).

Inexperienced researchers (i.e., early career researchers and potentially those in countries with less money available for education, research, and scientific development) may have less knowledge on how to navigate legitimate publishing due to limited experience with it than their more experienced counterparts. This may provide some rationale as to why there is an association between low number of publications and publications in predatory journals (90). A Kenyan researcher who participated in the first-ever massive online course about scholarly publishing for low income country researchers (run by Research4Life) exemplified this potential knowledge gap in a statement he provided after taking the course.

"The course was an eye-opener to me. I used to hear my colleagues mention words like bibliometrics, Scopus, Dimensions, ClinicalKey. I would wonder which

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[16] https://doaj.org/search, accessed May 29, 2020, selecting for "Agriculture", "Medicine", "Science", and "Technology" subjects/sub-subjects

[17] https://data.worldbank.org/country/india

world they were coming from. I now have a clearer concept of this hidden world of academia" (132)

While there is likely a dearth of formal training on scholarly publishing (97), researchers from higher income countries may have access to more resources, opportunities, and mentorship around aspects of scientific publishing (i.e., library training on databases, journals, and searching for literature) than researchers in countries with less investments in research and development (including less training and infrastructure (7)). As a result, the former may possess knowledge of and familiarity with scholarly publishing that the latter do not. This may result in differences in how experienced and inexperienced researchers select journals in which to publish. The resulting potential for researchers to mistake predatory journals for legitimate journals may be greater if they have less publishing experience.

Potentially intersecting with experience-based and income-based disparities is that many researchers do not speak English as their native language. English is the *lingua franca* of modern day scientific communication (133,134). In 2018, 78% of presumed legitimate peer reviewed, scientific journals were published in English (7) and many non-native English speakers opt to publish in these. This may be due to their higher rate of inclusion in the databases that academic scientists are rewarded for publishing in. In Italy, for example, 90% of scientific journal articles are published in English while only 10% or social sciences and humanities research is (84). The major publishers of scientific research are primarily headquartered in high-income countries and predominantly publish in English (7). By nature of not speaking English as a first or primary language, some researchers around the world are at a disadvantage in the current legitimate publishing environment. This is exemplified in a quote from an early career researcher from Hong Kong in the 1990's about the difficulty he faced when attempting to publish in English-language journals "What makes me feel bad is I get letters from the reviewer, and in the first two sentences it will say this is definitely not written by a native speaker—they shouldn't point this out as part of the main criteria for rejecting the article." (135). The same researcher also described his motivation for attempting English-language publication, "I don't like to write in Chinese but not because I hate Chinese but simply because the Chinese journals are not recognized – the English article will count more than the Chinese one." (135). Peer review at English-language journals, which represent the majority of legitimate publishing (7), may not serve non-native English speakers as well as it does native English speakers.

Predatory journals may be benefitting from or even capitalizing on the multiple intersecting disparities in legitimate publishing, thus attracting researchers who typically fall into the 'periphery' of scholarly publishing. For instance, the average APC identified in predatory journals (across disciplines) was $178 USD in 2014 (69), which is substantially less than the cost of publishing in legitimate open access journals. Comparatively lower APC pricing in predatory journals may make them more appealing or, indeed, the only option for some researchers who cannot secure or afford publication elsewhere. Researchers with little previous publishing experience/knowledge due to income-related barriers, those who cannot afford the costs associated with open access publishing, and non-native English speakers may be forced to seek

out low-barrier or low-cost publishing options (including predatory journals) in order to partake in the scholarly discourse. In some countries this may be compounded by publication-based career advancement requirements (see "The academic incentive").

Predatory publishing is a threat to scientific integrity

Lastly, there are concerns that predatory journals compromise the integrity of science (46,136–138). At least two sides exist in this argument. Some argue that predatory journals are allowing untrustworthy research into the scientific record (4,46,139), while others believe they are problematic because they are withholding potentially valuable research from the scientific record (140). These arguments are at odds with each other and require further consideration.

1. Predatory journals are 'polluting' the scholarly record.

Many in the scientific and publishing communities have called for researchers to be steered away from publishing in predatory journals or from reading and citing them, insisting that their content is fake or represents heavily flawed science (46,53,141). In addition to the seminal "sting" to expose predatory publishing operations in 2013 (11), other similar investigations to expose the flawed processes of predatory journals have been conducted (11,142,143). For example, one paper submitted to and accepted by a predatory journal simply contained the words "Get me off your fucking mailing list" repeated over 10 pages in a format resembling a typical scholarly article (144). Another article about cell entities that power Jedi in *Star Wars* was accepted by four of the nine predatory journals it was sent to (145). One concern resulting from such exposés is that predatory journals will publish research that is purposely fabricated or spun to meet particular agendas (e.g., political, financial). Headlines exist suggesting this is possible (e.g., "E-Cig Giant Juul Touts Positive Study in a Questionable Journal" (146)).

'Pollution' of the scholarly record from predatory journals, however, is likely limited. Repeated attempts to demonstrate the infiltration of predatory journals in bibliographic and citation databases demonstrate the inconsistent and relatively infrequent inclusion of their content (147–149). Around 2013, concerns began to surface that predatory journals listed on Beall's list were appearing in curated, scholarly databases such as the DOAJ, Scopus, and PubMed (23,85)[18]. Many such organizations running such indices have since revisited and strengthened their vetting criteria such that the journals they include are assured to use pre-specified practices (i.e., transparent policies, digital content preservation, article-level meta-data) (150–152), and that their content has been peer reviewed (153). This means that content from predatory journals that now appears in curated databases may be the result of one of four scenarios: (1) it may be a relic of pre-vetting/re-vetting processes; (2) it may be from journals that have either improved their practices and meet current vetting criteria; (3) it may be from journals that Beall labelled as predatory but that meet minimum vetting criteria (i.e., potential false positive); or (4) in PubMed, it may be the result of researchers uploading scientific articles to PubMed Central (PMC) in adherence with

[18] Google Scholar is not a curated database (182) and as such is not included in the discussion here.

funders' open access policies. PMC is the National Institutes of Health's open access archive for NIH-funded research. Many journals have agreements to automatically upload content to PMC due to NIH policies that all funded research be made publicly accessible (irrespective of where it is published). Knowing this, it is possible to conclude that some research published in predatory journals and appearing in trusted databases may be of some scientific value.

Concerns about the scholarly record being compromised by predatory journals ought to be weighed against potential harm from other sources (tangential argument - Appendix 1). For instance, the influence of industry through scientific journals and publications is not novel or limited to predatory journals (154). Additionally, in the current age of scientific misinformation, where research is published may be of little consequence to decision-makers (155). As such, the trustworthiness of the research being shared, independent of scholarly publishing, ought to be of primary concern.

2. Predatory journals are preventing research from entering the scientific record

Before we can assume that the pernicious influence of predatory journals has been averted due to their limited and inconsistent discoverability, the corollary is that some scientific content has gone missing because of them. As hundreds of thousands of researchers globally continue to publish in predatory journals (80,156,157), can we be certain that all they are sending to predatory journals is fake, silly, or compromised research? Before such an assumption can be made, there exists a need to systematically characterise the scientific contributions in predatory journals. This includes systematically determining where they are from, what types of studies they report, and the quality of such reporting. Such information ought to help understand the extent of the problem presented by predatory journal.

The argument that predatory journals are problematic because they publish fraudulent research or that of compromised integrity is weakened by the fact that such research is also published, often undetected, in legitimate journals (158). When positioned against predatory journals, by default the narrative is that legitimate journals are sources of trustworthy research. However, the propensity for the legitimate scientific literature to contain inadequacies, errors, and distortions, is discussed in one of the most highly cited and discussed scientific articles of all time, "Why most published research findings are false" authored by Stanford epidemiologist John Ioannidis (60). Such research, however, seems to be an accepted part of the scientific process to be accounted for in meta-syntheses or through the self-correcting nature of science (although such correction does not always happen as intended) (159). In reference to the legitimate scientific record, Ioannidis surmises that "perpetuated and unchallenged fallacies may comprise the majority of the circulating evidence" (159). It is possible that some of the research in predatory journals is no better or worse than some of what is contained in legitimate journals. However, the absence of evidence characterising their scientific content makes this determination or any conclusions about their potential impact on scientific integrity impossible.

Both of the above situations are troubling and demonstrate that predatory journals may be impacting the integrity of the scientific record. For instance, if research in predatory journals *is* entering the scientific record, we require a better understanding of whether it can be trusted.

Further, and possibly more problematic, is if potentially trustworthy research in predatory journals is not entering the scientific record, resulting in potentially valuable research not being available/found by those tasked with summarizing evidence (i.e., systematic reviewers) to inform future research, health care decisions, and health/health care policies.

Thesis Objectives

Predatory journals have disturbed pre-existing notions of scientific publishing and how it is expected to operate. This thesis was initiated at a time when leading opinions and discussions about predatory publishing were largely guided by experiences, emotions, and sometimes even potentially xenophobic sentiments [19]. Little empirical evidence existed to guide discussions and to further our understanding of them, yet they appear to be publishing an increasing volume of research (69,156). To understand the extent and way in which they may be problematic for publishing and for the scientific enterprise overall, further research is needed. Most immediately, a better understanding of how predatory journals appear, particularly in comparison to legitimate journals, is needed (Chapter 2). We also require more comprehensive knowledge of the characteristics of their scientific content in order to draw meaningful conclusions about their impact on science and on scientific publishing (Chapter 4). Lastly, it is clear that decisions on where researchers opt to publish may be influenced in different ways. Chapter 6 aims to understand whether and how research funders, who are largely relied on to support the fees associated with publishing, advise researchers where to publish. The specific research questions guiding the research in this thesis are as follows:

1. Do presumed biomedical predatory journals differ in apparent operations from presumed biomedical legitimate journals? (Chapter 2)
2. What are the epidemiological and reporting characteristics of research published in predatory journals? (Chapter 4)
3. Do health research funding agencies have policies guiding researchers on expected practices in publishing funded research? (Chapter 6)

Structure of the thesis

This thesis comprises three research projects corresponding to the objectives listed above. Two of three research chapters (Chapters 2 and 4) were published at the time of submitting this thesis and have been replicated and reformatted for the purpose of this thesis. Chapter 6 is prepared for submission to a journal and is not yet published. No modifications have been introduced into any

[19] In one instance Beall lamented, "I think the industry will continue to select for publishers like these [predatory]…so the future of the scholarly publishing industry looks very much like the textile industry, with most production moved to low-wage countries." (45).

published text; where recommended by the thesis advisory committee, additional clarifications appear in appendices. The three research chapters are interspersed by two short discussion chapters (Chapters 3 and 5) explaining how the forthcoming chapter builds on the previous project(s). The final chapter (Chapter 7) is a summary and discussion of the overall findings from this thesis, as well as implications for practice and recommendations for future research.

Positionality Statement

My views and understanding of the scholarly publishing landscape have evolved over the course of this research as a result of my increasing knowledge in the subject area and my evolving personal identity. The research contained in this thesis (Chapters 2, 4, and 6) was conducted from the lens of a member of a highly productive research team residing in a high-income country (Canada), and a degree of social capital gained from my various research achievements. I, along with colleagues in my network, had encountered few barriers to conducting and publishing research. While I understood this to be an exceptional and privileged experience, I had few reference points for norms and cultures of research and publishing outside of my direct experience. After I had completed, and mostly published my thesis research, I began writing the discussion chapters of this thesis (Chapters 1, 3, 5, and 7). This period coincided with my identity evolving as a new mother and with my subsequent decision to not return to work in order to complete my thesis. This uninterrupted time away from a research group together with increasing experience (and barriers) navigating an academic career as a new parent, sensitized me to the additional barriers faced by academic researchers with other and potentially intersecting identities (e.g., non-native English speaker, low socioeconomic status, resident of lower income country, racialized, female, early career). In my case, as a racialized, early career, mother, I was aware that the odds were against my academic success due to structural biases present in academia and in publishing (i.e., the stick against which academic achievement is measured). However, I am also acutely cognizant that my past track record and experiences may contribute to any future academic and publishing successes and that this is not a career advancement strategy available to most. As a result of this growing awareness, I began to view and interpret the research I had done with a new lens – that of someone for whom barriers to research and publishing may now exist. This new perspective is reflected in the aforementioned discussion chapters.

Box 1 Terminology and definitions used throughout this thesis.

Scholarly Publishing: For the purpose of this thesis, refers primarily to the publication of scholarly work in peer reviewed journals.

Science: For the purpose of this thesis, a collective term referring to the scholarly disciplines of science (natural, agricultural), technology (including mathematics, engineering), and medicine (including health) (184). In contrast, humanistic disciplines include arts, literature, and humanities (184). Disciplines such as social sciences and psychology are acknowledged to straddle both scientific and humanistic fields of research and may be considered science in some contexts (185).

Scientific Publishing: Scholarly publishing pertaining to science as defined above (7); a distinction is made because a published article is the preeminent form of scholarly communication (186–188) compared to in humanistic disciplines monographs and books are additionally central (184). The majority of scholarly journal publishing comprises scientific journal publishing.

Legitimate Journal: There does not appear to be a universal definition of what constitutes a scholarly journal. For the purpose of this thesis, this term will refer to the *concept* of a genuine scholarly journal publishing operation rather than to a specific entity that can be identified through a tangible source. Legitimate journals are theoretically assumed to use credible and legal practices (some practices, such as 'deception', used by some predatory journals that have been ruled illegitimate (40)). Where no descriptor precedes the word 'journal' in this thesis, readers can assume "legitimate journal" is the reference point.

Predatory Journal/publisher: For the purpose of this thesis, predatory journals/publishers designated as such by Jeffrey Beall (189). What constitutes/ought to constitute predatory publishing entities is discussed/debated throughout this thesis.

Trustworthy research: For the purpose of this thesis, research which is not fraudulent (i.e., falsified, fabricated, or plagiarised (190)) or erroneous, and which is replicable and transparently reported (191).

Lower income country: For the purpose of this thesis, countries defined by the World Bank as having low-income or lower-middle-income economies (192).

Higher income country: For the purpose of this thesis, countries defined by the World Bank as having high-income or upper-middle-income economies (192).

References

1. Butler D. Investigating journals: The dark side of publishing. Nature. 2013 Mar 27;495(7442):433–5.

2. Greco AN. The impact of disruptive and sustaining digital technologies on scholarly journals. Vol. 48, Journal of Scholarly Publishing. University of Toronto Press; 2016. p. 17–39.

3. Beall J. Predatory publishers are corrupting open access. Nature. 2012;489:179.

4. Bartholomew RE. Science for sale: the rise of predatory journals. J R Soc Med. 2014 Oct 30;107(10):384–5.

5. Tsuyuki RT, Al Hamarneh YN, Bermingham M, Duong E, Okada H, Beall J. Predatory publishers: Implications for pharmacy practice and practitioners. Vol. 150, Canadian Pharmacists Journal. Canadian Pharmacists Association; 2017. p. 274–5.

6. American Medical Writers Association, European Medical Writers Association, International Society for Medical Publication Professionals. AMWA–EMWA–ISMPP joint position statement on predatory publishing. Curr Med Res Opin. 2019 Sep 2;35(9):1657–8.

7. Johnson R, Watkinson A, Mabe M. The STM Report An overview of scientific and scholarly publishing. 5th Edition. The Hague; 2018.

8. Beall J. "Predatory" Open-Access Scholarly Publishers. Charlest Advis. 2010;11(4):10–7.

9. Roberts J. Predatory Journals: Illegitimate Publishing and Its Threat to All Readers and Authors. Vol. 13, Journal of Sexual Medicine. Elsevier B.V.; 2016. p. 1830–3.

10. Xia J. Predatory journals and their article publishing charges. Learn Publ. 2015 Jan 1;28(1):69–74.

11. Bohannon J. Who's afraid of peer review. Science. 2013;342:60–5.

12. Beall J. [Archived] Scholarly Open Access | Critical analysis of scholarly open-access publishing [Internet]. Scholarly Open Access. 2017 [cited 2020 Feb 5]. Available from: https://web.archive.org/web/20170103170903/https://scholarlyoa.com/

13. Beall J. Bentham Open. Charlest Advis. 2009;11(1):29–32.

14. Cabell's International. The Black List [Internet]. [cited 2019 Aug 4]. Available from: https://www2.cabells.com/about-blacklist

15. Anonymous. Beall's List – of Potential Predatory Journals and Publishers [Internet]. [cited 2019 Dec 12]. Available from: https://beallslist.net/

16. Anonymous. Stop Predatory Journals [Internet]. [cited 2019 Oct 18]. Available from:

https://predatoryjournals.com/

17. Eriksson S, Helgesson G. Time to stop talking about 'predatory journals'. Learn Publ. 2018 Apr 1;31(2):181–3.

18. COPE. Discussion document: Predatory Publishing. 2019 Nov.

19. Grudniewicz A, Moher D, Cobey KD, Bryson GL, Cukier S, Allen K, et al. Predatory journals: no definition, no defence. Nature. 2019 Dec 11;576(7786):210–2.

20. Siler K. There is no black and white definition of predatory publishing [Internet]. LSE Impact of Social Sciences. 2020 [cited 2020 May 14]. Available from: https://blogs.lse.ac.uk/impactofsocialsciences/2020/05/13/there-is-no-black-and-white-definition-of-predatory-publishing/

21. Crawford W. Ethics and Access 1: The Sad Case of Jeffrey Beall. Cites & Insights. 2014;14(4):1–14.

22. Berger M, Cisarella J. Beyond Beall's List: Better understanding predatory publishers. Coll Res Libr News. 2015;76(3):132–5.

23. Crawford W. Journals, "Journals" and Wannabes: Investigating The List. Cites & Insights. 2014;14(7):1–45.

24. Teixeira da Silva JA. Caution with the continued use of Jeffrey Beall's "predatory" open access publishing lists. AME Med J. 2017 Jun 7;2:97–97.

25. Kimotho SG. The storm around Beall's List: a review of issues raised by Beall's critics over his criteria of identifying predatory journals and publishers. African Res Rev. 2019 Apr 16;13(2):1.

26. Beall J. Criteria for Determining Predatory Open-Access Publishers. 3rd Edition. 2015.

27. Teixeira da Silva JA, Tsigaris P. What Value Do Journal Whitelists and Blacklists Have in Academia? J Acad Librariansh. 2018 Oct 22;

28. Bloudoff-Indelicato M. Backlash after Frontiers journals added to list of questionable publishers. Nature. 2015 Oct 23;526(7575):613.

29. Jones P. Defending Regional Excellence in Research or Why Beall is Wrong About SciELO [Internet]. The Scholarly Kitchen. 2015 [cited 2020 Feb 8]. Available from: https://scholarlykitchen.sspnet.org/2015/08/10/defending-regional-excellence-in-research-or-why-beall-is-wrong-about-scielo/

30. Esposito J. Parting Company with Jeffrey Beall [Internet]. The Scholarly Kitchen. 2013 [cited 2019 Dec 29]. Available from: https://scholarlykitchen.sspnet.org/2013/12/16/parting-company-with-jeffrey-beall/

31. Marusic A. Discussing predatory journals – EASE at the 5th World Conference on Research Integrity. Eur Sci Ed. 2017;2(431).

32. Stojanovski J, Marušić A. Does small equal predatory? Analysis of publication charges and transparency of editorial policies in Croatian open access journals. Biochem Medica. 2017 Jun 15;27(2):292–9.

33. DOAJ. Some journals say they are indexed in DOAJ but they are not [Internet]. DOAJ News Service. 2014 [cited 2020 May 5]. Available from: https://blog.doaj.org/2014/08/28/some-journals-say-they-are-in-doaj-when-they-are-not/

34. Spears T. The editor is deceased: Fake science journals hit new low. Ottawa Citizen. 2016 May 11;

35. Sorokowski P, Kulczycki E, Sorokowska A, Pisanski K. Predatory journals recruit fake editor. Nature. 2017 Mar 22;543(7646):481–3.

36. Bohannon J. Feature: How to hijack a journal. Science (80-). 2015 Nov 19;

37. Puzic S. Canadian medical journals hijacked for junk science [Internet]. The Toronto Star. 2016 [cited 2020 May 8]. Available from: https://www.thestar.com/news/world/2016/09/29/canadian-medical-journals-hijacked-for-junk-science.html

38. Deprez EE, Chen C. Medical Journals Have a Fake News Problem. Bloomberg Businessweek. 2017 Aug;

39. Brown PO, Eisen MB, Varmus HE. Why PLoS became a publisher. Vol. 1, PLoS Biology. Public Library of Science; 2003.

40. Court Rules in FTC's Favor Against Predatory Academic Publisher OMICS Group; Imposes $50.1 Million Judgment against Defendants That Made False Claims and Hid Publishing Fees [Internet]. Federal Trade Commission Press Releases. 2019 [cited 2019 Jun 10]. Available from: https://www.ftc.gov/news-events/press-releases/2019/04/court-rules-ftcs-favor-against-predatory-academic-publisher-omics

41. Anderson K. CrossRef Terminated OMICS' Membership [Internet]. The Geyser. 2019 [cited 2020 May 15]. Available from: https://thegeyser.substack.com/p/crossref-terminated-omics-membership

42. Anderson K. Is OMICS Using Knock-off DOIs? [Internet]. The Geyser. 2020 [cited 2020 May 15]. Available from: https://thegeyser.substack.com/p/is-omics-using-knock-off-dois

43. CrossRef. 2020.

44. Anderson K. UPDATED — 96 Things Publishers Do (2016 Edition) [Internet]. The Scholarly Kitchen. 2016 [cited 2020 May 16]. Available from: https://scholarlykitchen.sspnet.org/2016/02/01/guest-post-kent-anderson-updated-96-

things-publishers-do-2016-edition/

45. Esposito J. An Interview with Jeffrey Beall [Internet]. The Scholarly Kitchen. 2016 [cited 2020 Feb 28]. Available from: https://scholarlykitchen.sspnet.org/2016/02/08/an-interview-with-jeffrey-beall/

46. Beall J. Ban predators from the scientific record. Nature. 2016 Jun 15;534(7607):326–326.

47. Beall J. Predatory publishing is just one of the consequences of gold open access. Learn Publ. 2013 Apr 1;26(2):79–83.

48. Beall J. The Open-Access Movement is Not Really about Open Access. tripleC. 2013;11(2):589–97.

49. Jeffrey Beall - Wikipedia [Internet]. [cited 2020 Feb 24]. Available from: https://en.wikipedia.org/wiki/Jeffrey_Beall

50. Jacobson MW. Biomedical publishing and the Internet: Evolution or revolution? Vol. 7, Journal of the American Medical Informatics Association. Hanley and Belfus Inc.; 2000. p. 230–3.

51. Poynder R. Interview with Vitek Tracz: Essential for Science. Information Today. 2005;

52. Crawford W. GOAJ3: Gold open access journals 2012-2017. 3rd ed. Livermore, CA; 2018.

53. Moher D, Moher E. Stop Predatory Publishers Now: Act Collaboratively. Ann Intern Med. 2016 May 3;164(9):616.

54. Solomon DJ, Björk B-C. Publication fees in open access publishing: Sources of funding and factors influencing choice of journal. J Am Soc Inf Sci Technol. 2012 Jan;63(1):98–107.

55. Michie S, van Stralen MM, West R. The behaviour change wheel: a new method for characterising and designing behaviour change interventions. Implement Sci. 2011 Jan;6(1):42.

56. Hammarfelt B. Recognition and reward in the academy: Valuing publication oeuvres in biomedicine, economics and history. Aslib J Inf Manag. 2017;69(5):607–23.

57. Rice DB, Raffoul H, Ioannidis JP, Moher D. Academic criteria for promotion and tenure in faculties of biomedical sciences: a cross-sectional analysis of 146 universities. bioRxiv. 2019 Oct 21;802850.

58. Galasiński D. Ghent's choices [Internet]. Dariusz Galasiński Blog. 2019 [cited 2020 Feb 20]. Available from: http://dariuszgalasinski.com/2019/01/02/ghents-choices/

59. Ioannidis JPA, Khoury MJ. Assessing Value in Biomedical Research: The PQRST of Appraisal and Reward. JAMA. 2014 Aug 6;312(5):483.

60. Ioannidis JPA. Why Most Published Research Findings Are False. PLoS Med. 2005 Aug

30;2(8):e124.

61. Neff MW. How Academic Science Gave Its Soul to the Publishing Industry. Issues Sci Technol. 2020;36((WInter 2020) 2):35–43.

62. Pavel A-P. Global university rankings-a comparative analysis. Procedia Econ Financ. 2015;26:54–63.

63. Song F, Loke Y, Hooper L. Why Are Medical and Health-Related Studies Not Being Published? A Systematic Review of Reasons Given by Investigators. Wicherts JM, editor. PLoS One. 2014 Oct 15;9(10):e110418.

64. Lakhotia SC. Mis-Conceived and Mis-Implemented Academic Assessment Rules Underlie the Scourge of Predatory Journals and Conferences. Proc Indian Natl Sci Acad. 2017 Aug 1;94.

65. University Grants Commission. UGC Regulations 2010 - Minimum qualifications for appointment of teachers and other academic staff in universities and colleges and measures for the maintenance of standards in higher education. Gaz India. 2010;September:7848–996.

66. Lakhotia SC. 'National' versus 'International' Journals. Curr Sci. 2013;105(3):287–8.

67. Lakhotia SC. Predatory journals and academic pollution. Curr Sci. 2015;108(8):1407.

68. Kogleck L, Priyadarshini S, Pincock S, Bocquet A, Gilloch C. Nature Index analysis 2014: India's ascent towards world-class science [Internet]. Nature Index. 2015 [cited 2020 May 13]. Available from: https://www.natureindex.com/custom-reports/indian-science-ascending/ascent-towards-world-class-science/

69. Shen C, Bjork B-C, Björk B. 'Predatory' open access: a longitudinal study of article volumes and market characteristics. BMC Med. 2015 Dec 1;13(1):230.

70. Pushkar. Straight Talk: India's higher education institutions need greater clarity of purpose [Internet]. braingainmag.com. 2018 [cited 2020 May 13]. Available from: https://www.braingainmag.com/india-s-higher-education-institutions-need-greater-clarity-of-purpose.htm

71. Tao T. India's Fight Against Predatory Journals: An Interview with Professor Bhushan Patwardhan [Internet]. The Scholarly Kitchen. 2020 [cited 2020 May 1]. Available from: https://scholarlykitchen.sspnet.org/2020/02/05/indias-fight-against-predatory-journals-an-interview-with-professor-bhushan-patwardhan/

72. University Grants Commission. UGC Regulations Amendment 2016 - Minimum qualifications for appointment of teachers and other academic staff in universities and colleges and measures for the maintenance of standards in higher education. Gaz India. 2016;July:1–39.

73. Kolata G. Many Academics Are Eager to Publish in Worthless Journals [Internet]. The New York Times. 2017 [cited 2020 Apr 30]. Available from: https://www.nytimes.com/2017/10/30/science/predatory-journals-academics.html?smid=tw-share

74. Omobowale AO, Sawadogo N, Sawadodo-Compaoré EMFW, Ugbem CE. Globalization and Scholarly Publishing in West Africa. Int J Sociol. 2013 Apr 8;43(1):8–26.

75. Omobowale AO, Akanle O, Adeniran AI, Adegboyega K. Peripheral scholarship and the context of foreign paid publishing in Nigeria. Beigel F, editor. Curr Sociol. 2014 Sep 17;62(5):666–84.

76. Ezinwa Nwagwu W, Ojemeni O. Penetration of Nigerian predatory biomedical open access journals 2007-2012: a bibiliometric study. Learn Publ. 2015;28:23–34.

77. Nicoll L, Chinn P. Caught in the Trap: The Allure of Deceptive Publishers. Nurse Author Ed. 2015;25(4):4.

78. Himmelstein D. The history of publishing delays [Internet]. 2016 [cited 2019 Dec 18]. Available from: https://blog.dhimmel.com/history-of-delays/

79. Powell K. The waiting game. Vol. 530, Nature. Nature Publishing Group; 2016. p. 148–51.

80. Hern A, Duncan P. Predatory publishers: the journals that churn out fake science. The Guardian. 2018;

81. Schekman R. How journals like Nature, Cell and Science are damaging science [Internet]. The Guardian. 2013 [cited 2019 Dec 21]. Available from: https://www.theguardian.com/commentisfree/2013/dec/09/how-journals-nature-science-cell-damage-science

82. Quan W, Chen B, Shu F. Publish or impoverish. Aslib J Inf Manag. 2017 Sep 18;69(5):486–502.

83. Hedding DW. Payouts push professors towards predatory journals. Nature. 2019 Jan 15;565(7739):267–267.

84. Bagues M, Sylos-Labini M, Zinovyeva N. A walk on the wild side: 'Predatory' journals and information asymmetries in scientific evaluations. Res Policy. 2019 Mar;48(2):462–77.

85. Macháček V, Srholec M. Predatory journals in Scopus. 2017.

86. Kolata G. Scientific article accepted (personal checks, too). The New York Times. 2013;

87. Shaw C. Hundreds of open access journals accept fake science paper [Internet]. The Guardian. 2013 [cited 2020 May 28]. Available from: https://www.theguardian.com/higher-education-network/2013/oct/04/open-access-journals-fake-paper

88. Moher D, Srivastava A. You are invited to submit…. BMC Med. 2015 Dec;13(1):180.

89. Clemons M, de Costa e Silva M, Joy AA, Cobey KD, Mazzarello S, Stober C, et al. Predatory Invitations from Journals: More Than Just a Nuisance? Oncologist. 2017 Feb;22(2):236–40.

90. Xia J, Harmon JL, Connolly KG, Donnelly RM, Anderson MR, Howard HA. Who publishes in "predatory" journals? J Assoc Inf Sci Technol. 2015 Jul;66(7):1406–17.

91. The Fallacy of Open-Access Publication - The Chronicle of Higher Education [Internet]. [cited 2020 May 5]. Available from: https://www.chronicle.com/article/The-Fallacy-of-Open-Access/241786

92. Smith R. Peer review: A flawed process at the heart of science and journals. Vol. 99, Journal of the Royal Society of Medicine. 2006. p. 178–82.

93. Smith R. Scrap peer review and beware of "top journals" [Internet]. The BMJ. 2010 [cited 2020 May 6]. Available from: https://blogs.bmj.com/bmj/2010/03/22/richard-smith-scrap-peer-review-and-beware-of-"top-journals"/

94. Rennie D. Let's make peer review scientific. Vol. 535, Nature. Nature Publishing Group; 2016. p. 31–3.

95. The Retraction Watch Leaderboard [Internet]. Retraction Watch. [cited 2020 Jun 28]. Available from: https://retractionwatch.com/the-retraction-watch-leaderboard/

96. Rabin RC. The Pandemic Claims New Victims: Prestigious Medical Journals [Internet]. The New York Times. 2020 [cited 2020 Jun 28]. Available from: https://www.nytimes.com/2020/06/14/health/virus-journals.html

97. Wager E. Why we should worry less about predatory publishers and more about the quality of research and training at our academic institutions. Vol. 27, Journal of Epidemiology. Japan Epidemiology Association; 2017. p. 87–8.

98. Schroter S, Roberts J, Loder E, Penzien DB, Mahadeo S, Houle TT. Biomedical authors' awareness of publication ethics: An international survey. BMJ Open. 2018 Nov 1;8(11).

99. Bell K. 'Predatory' Open Access Journals as Parody: Exposing the Limitations of 'Legitimate' Academic Publishing. tripleC Commun Capital Crit Open Access J a Glob Sustain Inf Soc. 2017 Jul 8;15(2):651–62.

100. Chan L, Cuplinskas D, Eisen M, Friend F, Genova Y, Guédon J-C, et al. Budapest Open Access Initiative [Internet]. 2002 [cited 2020 May 11]. Available from: https://www.budapestopenaccessinitiative.org/read

101. Doyle H, Gass A, Kennison R. Who Pays for Open Access? PLoS Biol. 2004 Apr 13;2(4):e105.

102. Laakso M, Welling P, Bukvova H, Nyman L, Björk B-C, Hedlund T, et al. The development of open access journal publishing from 1993 to 2009. Hermes-Lima M, editor. PLoS One. 2011

Jun 13;6(6):e20961.

103. Giles J. PR's 'pit bull' takes on open access. Vol. 445, Nature. Nature Publishing Group; 2007. p. 347.

104. Giles J. Societies take united stand on journal access. Vol. 428, Nature. Nature Publishing Group; 2004. p. 356.

105. Suber P. Open access: six myths to put to rest [Internet]. The Guardian. 2013 [cited 2020 May 6]. Available from: https://www.theguardian.com/higher-education-network/blog/2013/oct/21/open-access-myths-peter-suber-harvard

106. Haug CJ. No free lunch - What price plan s for scientific publishing? N Engl J Med. 2019 Mar 21;380(12):1181–5.

107. Wakeling S, Willett P, Creaser C, Fry J, Pinfield S, Spezi V. Open-Access Mega-Journals: A Bibliometric Profile. Dorta-González P, editor. PLoS One. 2016 Nov 18;11(11):e0165359.

108. Agrawal AA. Four more reasons to be skeptical of open-access publishing. Vol. 19, Trends in Plant Science. Elsevier Current Trends; 2014. p. 133.

109. van Rooyen S, Delamothe T, Evans SJ. Effect on peer review of telling reviewers that their signed reviews might be posted on the web: randomised controlled trial. BMJ. 2010 Nov 16;341:c5729.

110. Wicherts JM, Veldkamp CLS, Augusteijn HEM, Bakker M, van Aert RCM, van Assen MALM. Degrees of Freedom in Planning, Running, Analyzing, and Reporting Psychological Studies: A Checklist to Avoid p-Hacking. Front Psychol. 2016;7:1832.

111. Björk B-C, Solomon D. Open access versus subscription journals: a comparison of scientific impact. BMC Med. 2012 Jan 17;10(1):73.

112. Neuberger J, Counsell C. Impact factors: Uses and abuses. Vol. 14, European Journal of Gastroenterology and Hepatology. 2002. p. 209–11.

113. Laakso M, Björk BC. Hybrid open access—A longitudinal study. J Informetr. 2016 Nov 1;10(4):919–32.

114. Laakso M, Björk B-C. Delayed open access: An overlooked high-impact category of openly available scientific literature. J Am Soc Inf Sci Technol. 2013 Jul 1;64(7):1323–9.

115. Piwowar H, Priem J, Larivière V, Alperin JP, Matthias L, Norlander B, et al. The state of OA: a large-scale analysis of the prevalence and impact of Open Access articles. PeerJ. 2018 Feb 13;6(2):e4375.

116. Anderson K. Dropping the Hammer - Predatory Publishers Get Pounded by Regulators and the Press [Internet]. The Scholarly Kitchen. 2018 [cited 2020 May 15]. Available from: https://scholarlykitchen.sspnet.org/2018/07/30/dropping-hammer-predatory-publishers-

get-pounded-regulators-press/

117. Samulack D, Roberts J. Guest Post: Transparency – "This is What We Do, and This is What We Expect" [Internet]. The Scholarly Kitchen. 2018 [cited 2018 Dec 12]. Available from: https://scholarlykitchen.sspnet.org/2018/09/11/guest-post-transparency-this-is-what-we-do-and-this-is-what-we-expect/

118. Bryant K. Research from the global south: the important role of context in international research activities. McGill J Educ / Rev des Sci l'éducation McGill. 2014;49(1).

119. Harris M, Macinko J, Jimenez G, Mullachery P. Measuring the bias against low-income country research: An Implicit Association Test. Global Health. 2017 Nov 6;13(1):80.

120. Lundine J, Bourgeault IL, Clark J, Heidari S, Balabanova D. The gendered system of academic publishing. Vol. 391, The Lancet. Lancet Publishing Group; 2018. p. 1754–6.

121. Salager-Meyer F. Scientific publishing in developing countries: Challenges for the future. J English Acad Purp. 2008 Apr;7(2):121–32.

122. Neff MW. Publication incentives undermine the utility of science: Ecological research in Mexico. Sci Public Policy. 2018 Apr 1;45(2):191–201.

123. UN Department of Economic and Social Affairs. World Social Report 2020: Inequality in a rapidly changing world. 2020.

124. Björk BC. Growth of hybrid open access, 2009-2016. PeerJ. 2017;2017(9).

125. Solomon DJ, Laakso M, Björk B-C. A longitudinal comparison of citation rates and growth among open access journals. J Informetr. 2013 Jul;7(3):642–50.

126. Ellers J, Crowther TW, Harvey JA. Gold Open Access Publishing in Mega-Journals: Developing Countries Pay the Price of Western Premium Academic Output. J Sch Publ. 2017 Oct 1;49(1):89–102.

127. Solomon D, Björk B-C. Article processing charges for open access publication-the situation for research intensive universities in the USA and Canada. PeerJ. 2016;4:e2264.

128. Solomon DJ, Björk B-C. A study of open access journals using article processing charges. J Am Soc Inf Sci Technol. 2012 Aug 6;63(8):1485–95.

129. Lawson S. Fee Waivers for Open Access Journals. Publications. 2015 Aug 5;3(3):155–67.

130. Nobes A, Harris S. Open Access in developing countries – attitudes and experiences of researchers. 2019 Sep 30;

131. Gadagkar R. Open-access more harm than good in developing world. Vol. 453, Nature. Nature Publishing Group; 2008. p. 450.

132. First Research4Life MOOC: "I now have a clearer concept of the hidden world of academia"

[Internet]. Research4Life blog. 2020 [cited 2020 Feb 12]. Available from: https://www.research4life.org/blog/first-research4life-mooc-i-now-have-a-clearer-concept-of-the-hidden-world-of-academia/

133. Kamadjeu R. English: the lingua franca of scientific research. Lancet Glob Heal. 2019 Sep 1;7(9):e1174.

134. Monge-Nájera J. The countries and languages that dominate biological research at the beginning of the 21st century. Rev Biol Trop. 2005;52(1–2):283–94.

135. Flowerdew J. Discourse Community, Legitimate Peripheral Participation, and the Nonnative-English-Speaking Scholar. TESOL Q. 2000;34(1):127.

136. Manca A, Cugusi L, Dvir Z, Deriu F, Dvir Z, Deriu F. PubMed should raise the bar for journal inclusion. Lancet (London, England). 2017 Aug 19;390(10096):734–5.

137. Beall J. What I learned from predatory publishers. Biochem Medica. 2017 Jun 15;27(2):273–8.

138. Habibzadeh F, Simundic A-M. Predatory journals and their effects on scientific research community. Biochem Medica. 2017 Jun 15;27(2):270–2.

139. Beall J. Predatory Publishers Threaten to Erode Scholarly Communication. Sci Ed. 2013;36(1):18.

140. Ferris LE, Winker MA. Ethical issues in publishing in predatory journals. Biochem Medica. 2017 Jun 15;27(2):279–84.

141. Clark J, Smith R. Firm action needed on predatory journals. BMJ. 2015 Jan 16;350(jan16 1):h210–h210.

142. Stromberg J. 'Get Me Off Your Fucking Mailing List' is an actual science paper accepted by a journal [Internet]. Vox. 2014. Available from: www.vox.com/2014/11/21/7259207/scientific-paper-scam

143. Hello…Newman: Yet another sting pranks a predatory journal, Seinfeld-style – Retraction Watch [Internet]. 2017 [cited 2020 Feb 28]. Available from: http://retractionwatch.com/2017/04/06/hello-newman-yet-another-sting-pranks-a-predatory-journal-seinfeld-style/

144. Mazì D, Kohler E. Get me off Your Fucking Mailing List.

145. Neuroskeptic. Predatory Journals Hit By 'Star Wars' Sting [Internet]. Discover Magazine. 2017 [cited 2017 Aug 5]. Available from: http://blogs.discovermagazine.com/neuroskeptic/2017/07/22/predatory-journals-star-wars-sting/#.WlAZN1Q-fOR

146. Ault A. E-Cig Giant Juul Touts Positive Study in a Questionable Journal. Medscape. 2019;

147. Manca A, Martinez G, Cugusi L, Dragone D, Mercuro G, Deriu F. Predatory Open Access in Rehabilitation. Arch Phys Med Rehabil. 2017 May;98(5):1051–6.

148. Manca A, Martinez G, Cugusi L, Dragone D, Dvir Z, Deriu F. The surge of predatory open-access in neurosciences and neurology. Neuroscience. 2017 Jun 14;353:166–73.

149. Demir SB. Scholarly databases under scrutiny. J Librariansh Inf Sci. 2020 Mar 29;52(1):150–60.

150. DOAJ. Myth-busting: DOAJ indexes "predatory" journals [Internet]. DOAJ News Service. 2019 [cited 2020 May 5]. Available from: https://blog.doaj.org/2019/08/05/myth-busting-doaj-indexes-predatory-journals/

151. US National Library of Medicine. Fact Sheet MEDLINE® Journal Selection [Internet]. U.S. National Library of Medicine; [cited 2019 Dec 5]. Available from: https://www.nlm.nih.gov/lstrc/jsel.html

152. Scopus. Scopus Policy and Content Selection [Internet]. 2020 [cited 2020 Apr 23]. Available from: https://www.elsevier.com/solutions/scopus/how-scopus-works/content/content-policy-and-selection

153. US National Institutes of Health. How Papers Get Into PMC [Internet]. 2015 [cited 2020 Jan 24]. Available from: https://www.ncbi.nlm.nih.gov/pmc/about/submission-methods/

154. Lundh A, Lexchin J, Mintzes B, Schroll JB, Bero L. Industry sponsorship and research outcome. Cochrane database Syst Rev. 2017 Feb 16;2(2):MR000033.

155. Sayare S. He Was a Science Star. Then He Promoted a Questionable Cure for Covid-19. [Internet]. The New York Times. 2020 [cited 2020 May 14]. Available from: https://www.nytimes.com/2020/05/12/magazine/didier-raoult-hydroxychloroquine.html

156. More than 5,000 German scientists have published papers in pseudo-scientific journals [Internet]. [cited 2020 Jan 27]. Available from: https://www.ndr.de/der_ndr/presse/More-than-5000-German-scientists-have-published-papers-in-pseudo-scientific-journals,fakescience178.html

157. Oberhaus D. Hundreds of Researchers From Harvard, Yale and Stanford Were Published in Fake Academic Journals. VICE. 2018;

158. Young NS, Ioannidis JPAA, Al-Ubaydli O. Why Current Publication Practices May Distort Science. PLoS Med. 2008 Oct 7;5(10):e201.

159. Ioannidis JPA. Why Science Is Not Necessarily Self-Correcting. Perspect Psychol Sci. 2012 Nov 7;7(6):645–54.

160. Smith R. Medical journals and pharmaceutical companies: Uneasy bedfellows. Vol. 326, British Medical Journal. BMJ Publishing Group; 2003. p. 1202–5.

161. The National Academies (US) Committee on Electronic Scientific T and MJP. Publication Business Models and Revenue. 2004;

162. Smith R. Should medical journals carry drug advertising? Yes. BMJ. 2007 Jul 14;335(7610):74.

163. Williams G. Should medical journals carry drug advertising? No. Vol. 335, BMJ (Clinical research ed.). British Medical Journal Publishing Group; 2007. p. 75.

164. David P. Elsevier Published Fake Journals [Internet]. The Scholarly Kitchen. 2009 [cited 2019 Dec 3]. Available from: https://scholarlykitchen.sspnet.org/2009/05/07/elsevier-published-fake-journals/

165. Washington HA. Flacking for Big Pharma [Internet]. The American Scholar. 2011 [cited 2020 May 8]. Available from: https://theamericanscholar.org/flacking-for-big-pharma/#.XrUh6RNKjOQ

166. Godlee F, Abbasi K, Bloom T. BMJ declares its revenues from industry. BMJ. 2017 Oct 25;j4930.

167. BMJ. Sources of revenue [Internet]. The BMJ. 2020 [cited 2020 May 8]. Available from: https://www-bmj-com.proxy.bib.uottawa.ca/about-bmj/sources-of-revenue

168. Smith R. The trouble with medical journals. Royal Society of Medicine Press Ltd; 2006. 292 p.

169. Dyer O. Journal rejects article after objections from marketing department. BMJ. 2004;328(7434):244.

170. Roth Y, Pickles N. Updating our Approach to Misleading Information [Internet]. Twitter blog. 2020 [cited 2020 May 16]. Available from: https://blog.twitter.com/en_us/topics/product/2020/updating-our-approach-to-misleading-information.html

171. FDA. Coronavirus (COVID-19) Update: FDA Reiterates Importance of Close Patient Supervision for 'Off-Label' Use of Antimalarial Drugs to Mitigate Known Risks, Including Heart Rhythm Problems [Internet]. FDA Press Announcements. 2020 [cited 2020 May 16]. Available from: https://www.fda.gov/news-events/press-announcements/coronavirus-covid-19-update-fda-reiterates-importance-close-patient-supervision-label-use

172. American Medical Association, American Pharmacists Association, American Society of Health-System Pharmacist. Joint statement on ordering, prescribing or dispensing COVID-19 medications [Internet]. AMA Statements. 2020 [cited 2020 May 14]. Available from: https://www.ama-assn.org/delivering-care/public-health/joint-statement-ordering-prescribing-or-dispensing-covid-19

173. Talpos S. Is Hydroxychloroquine Making Covid-19 Clinical Trials Harder? [Internet]. Undark. 2020 [cited 2020 May 14]. Available from:

https://undark.org/2020/04/09/hydroxychloroquine-covid-19-clinical-trials-harder/

174. Hydroxychloroquine and azithromycin as a treatment of COVID-19.pdf - Google Drive [Internet]. [cited 2020 Aug 18]. Available from: https://drive.google.com/file/d/186Bel9RqfsmEx55FDum4xY_IlWSHnGbj/view

175. Curb LA, Abramson CI. An Examination of Author-Paid Charges in Science Journals. Compr Psychol. 2012 Jan 1;1:01.17.CP.1.4.

176. Sugimoto CR, Larivière V, Ni C, Cronin B. Journal acceptance rates: A cross-disciplinary analysis of variability and relationships with journal measures. J Informetr. 2013 Oct 1;7(4):897–906.

177. Björk B-C, Catani P. Peer review in megajournals compared with traditional scholarly journals: Does it make a difference? Learn Publ. 2016 Jan 20;29(1):9–12.

178. Charbonneau DH, McGlone J. Faculty experiences with the National Institutes of Health (NIH) public access policy, compliance issues, and copyright practices. J Med Libr Assoc. 2013;101(1):21–5.

179. Khoo SY-S, Lay BPP. A Very Long Embargo: Journal Choice Reveals Active Non-Compliance with Funder Open Access Policies by Australian and Canadian Neuroscientists. Lib Q. 2018 Oct;28(1):xx–xx.

180. Okerson A, Stubes K. The Library 'Doomsday Machine' (sharp price increases for scholarly journals). Publ Wkly. 1991;238(8):36–7.

181. Big Deal Cancellation Tracking - SPARC [Internet]. [cited 2019 Dec 3]. Available from: https://sparcopen.org/our-work/big-deal-cancellation-tracking/

182. Buneman P. Curated Databases. In: Agostini M, Borbinha J, Kapidakis S, Papatheodorou C, Tsakonas G, editors. Research and Advanced Technology for Digital Libraries. Lecture No. Berlin, Heidelberg: Springer; 2009. p. 2–2.

183. Coronavirus (COVID-19) Update: FDA Revokes Emergency Use Authorization for Chloroquine and Hydroxychloroquine. FDA News Release. 2020;

184. Anderson R. Scholarly Communication : What Everyone Needs to Know. New York: Oxford University Press; 2018.

185. Bunge M. What kind of discipline is psychology: Autonomous or dependent, humanistic or scientific, biological or sociological? New Ideas Psychol. 1990 Jan 1;8(2):121–37.

186. Schaffner A. The future of scientific journals: lessons from the past. Inf Technol Libr. 1994;13(4):239.

187. Solomon DJ. Digital Distribution of Academic Journals and its Impact on Scholarly Communication: Looking Back After 20Years. J Acad Librariansh. 2013 Jan;39(1):23–8.

188. McDougall-Waters J, Moxham N, Fyfe A. Philosophical Transactions: 350 years of publishing at the Royal Society (1665 – 2015). 2015.

189. Beall J. Scholarly Open Access [Internet]. 2017 [cited 2017 Jan 1]. Available from: http://web.archive.org/web/20170103170903/https://scholarlyoa.com/

190. Dal-Ré R, Bouter LM, Cuijpers P, Gluud C, Holm S. Should research misconduct be criminalized? Res Ethics. 2020 Jan 16;174701611989840.

191. Jamieson KH, McNutt M, Kiermer V, Sever R. Signaling the trustworthiness of science. Proc Natl Acad Sci. 2019 Sep 24;116(39):19231–6.

192. The World Bank. World Bank Country and Lending Groups [Internet]. [cited 2020 Jul 16]. Available from: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

Appendix 1

Harm from predatory journals vs other scholarly communications?

The potential 'pollution' of the scholarly record with fabricated, falsified, or otherwise untrustworthy content from predatory journals may be minimal relative to other sources of such content, particularly that from industry or agenda-driven sources.

According to Richard Smith (former editor-in-chief of the *British Medical Journal [BMJ]*) in 2003, "all journals are bought – or at least cleverly used – by the pharmaceutical industry" (160). A wealth of evidence shows that industry-sponsored studies published in legitimate journals are consistently more favourable towards sponsor's products than non-industry funded studies (154). Such selective publication of favourable findings (i.e., publication bias) may outweigh published unfavourable findings in cumulative evidence syntheses (i.e., in meta-analyses) and result in claims of overexaggerated effects (i.e., that emphasize benefits and downplay harms). In addition, 'industry funding' comprises a substantial proportion of revenues for some legitimate journals (161), in the form of print and digital advertisements, reprints of industry-sponsored studies (subsequently delivered to practicing health professionals' inboxes), and industry-paid journal supplements (possibly containing only favourable studies about a companies' products, sometimes packaged as conference proceedings) (162,163). In 2009 it was revealed that the publisher *Elsevier* had launched six Australian journals between 2000 and 2005 with undisclosed sponsorship from Merck containing only reprints of favourable studies and reviews of Merck products (164). In 2011, industry advertising reportedly accounted for over 95% of some journals' revenues (165). The *BMJ,* which appears to be exceptionally transparent about its practices, started declaring its annual industry revenues in 2016 (166); most legitimate journals do not provide this information (167). In 2018 (the latest year reported at the time of writing) industry advertising represented 14.4% of *The BMJ's* total revenue (167). As articulated by Fiona Godlee, the current editor of *The BMJ*, "over-reliance on advertising can bring pressure on editors to avoid publishing articles that will upset drug or device manufacturers" (166). Indeed, numerous instances of legitimate journals' publishing revenues overriding scientific integrity have been publicly documented (165,168). One example is from the journal *Transplantation and Dialysis* (ceased operations in 2011). In 2003, its editor rejected a guest editorial questioning the evidence supporting epoetin in end stage renal disease, despite favourable peer reviews (169). Comments from the editor to the author (which were later publicized) revealed that the action was based on fear of losing advertising revenues from the drug's manufacturer (169). These examples illustrate that without transparent information about both predatory and legitimate journals' revenue sources, little evidence exists to support that the influence of industry is limited to/worse in predatory journals.

Another factor minimizing the impact of possible 'harm' from predatory journals to the evidence base is that the outlet in which research is published may have little bearing on its impact in the current age of scientific misinformation. Social media platforms, particularly Twitter, have become trusted sources of scientific information for the public and, importantly, for some politicians with decision-making authority such as US President, Donald Trump (170). Through this medium, for

example, an unpublished, poorly conducted small study claiming that off-label use of hydroxychloroquine (used to treat rheumatoid arthritis and lupus) 'cured' the 2019 novel coronavirus disease (COVID-19) made its way to Trump[20] (155). This not only prompted the President to start taking the drug (which has a known high risk of adverse effects (171) and which had unclear effectiveness against COVID-19 at the time)[21], but also to order regulatory approval for "emergency use" of the drug so that others could do the same. Consequently, the American public and health care providers to clamoured after limited supplies of the drug leaving the American Medical Association concerned that the supplies for patients who relied on hydroxychloroquine would be limited (172) and that there would be unnecessary strain on the drug discovery pipeline (173)[22]. This dramatic unfolding of events were based on a research that had been shared via Google Drive and not yet even published in a journal (174).

[20] https://twitter.com/JamesTodaroMD/status/1240274548165169157?s=20
[21] https://www.youtube.com/watch?v=1I9Bb8Fbui0
[22] "Emergency use" approval was revoked three months after first issue (183)

Chapter 2: Potential predatory and legitimate biomedical journals: can you tell the difference? A cross sectional comparison

Note: The text in this has been reproduced from the published article found in Appendix 4.

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Supplementary materials	Study Protocol: https://osf.io/6qghx/ Study Forms & Data: https://osf.io/2wj6c/ Examples of journal characteristics: https://osf.io/nxn7g/
Abbreviations	AIM: Abridged Index Medicus APC: article processing charge CONSORT: CONsolidated Standards Of Reporting Trials COPE: Committee On Publication Ethics DOAJ: Directory Of Open Access Journals EIC: editor-in-chief EQUATOR: Enhancing the QUAlity and Transparency of health Research ISSN: international standard serial number JIF: journal impact factor LMIC: low- or middle-income country OASPA: Open Access Scholarly Publishers Association PLOS: Public Library Of Science PRISMA: Preferred Reporting Items for Systematic reviews and Meta-Analyses STARD: STAndards for Reporting Diagnostic accuracy STROBE: STrengthening the Reporting of OBservational studies in Epidemiology USD: United States Dollar
Appendices	Appendix 1: Author Contributions Appendix 2: Post-hoc clarifications to published text Appendix 3: Examples of characteristics in predatory journals and legitimate journals Appendix 4: Published article Appendix 5: Copyright permission

Potential predatory and legitimate biomedical journals: can you tell the difference? A cross sectional comparison

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Abstract

Background: The Internet has transformed scholarly publishing, most notably, by the introduction of open access publishing. Recently, there has been a rise of online journals characterized as 'predatory', which actively solicit manuscripts and charge publications fees without providing robust peer review and editorial services. We carried out a cross-sectional comparison of characteristics of potential predatory, legitimate open access, and legitimate subscription-based biomedical journals.

Methods: On July 10, 2014, scholarly journals from each of the following groups were identified – potential predatory journals (source: Beall's List), presumed legitimate, fully open access journals (source: PubMed Central), and presumed legitimate subscription-based (including hybrid) journals (source: Abridged Index Medicus). MEDLINE journal inclusion criteria were used to screen and identify biomedical journals from within the potential predatory journals group. One hundred journals from each group were randomly selected. Journal characteristics (e.g., website integrity, look and feel, editors and staff, editorial/peer review process, instructions to authors, publication model, copyright and licensing, journal location, and contact) were collected by one assessor and verified by a second. Summary statistics were calculated.

Results: Ninety-three predatory journals, 99 open access, and 100 subscription-based journals were analyzed; exclusions were due to website unavailability. Many more predatory journals' homepages contained spelling errors (61/93, 66%) and distorted or potentially unauthorized images (59/93, 63%) compared to open access journals (6/99, 6% and 5/99, 5%, respectively) and subscription-based journals (3/100, 3% and 1/100, 1%, respectively). Thirty-one (33%) predatory journals promoted a bogus impact metric – the Index Copernicus Value – versus three (3%) open access journals and no subscription-based journals. Nearly three quarters (n = 66, 73%) of predatory journals had editors or editorial board members whose affiliation with the journal was unverified versus two (2%) open access journals and one (1%) subscription based journal in which this was the case. Predatory journals charge a considerably smaller publication fee (median $100 USD, IQR $63–$150) than open access journals ($1865 USD, IQR $800–$2205) and subscription-based hybrid journals ($3000 USD, IQR $2500–$3000).

Conclusions: We identified 13 evidence-based characteristics by which predatory journals may potentially be distinguished from presumed legitimate journals. These may be useful for authors who are assessing journals for possible submission or for others, such as universities evaluating candidates' publications as part of the hiring process.

Background

The Internet has transformed scholarly publishing. It has allowed for the digitalization of content and subsequent online experimentation by publishers, enabling print journals to host content online, and set the course for online open-access publishing. Nevertheless, an unwelcome consequence of the Internet age of publishing has been the rise of so-called predatory publishing.

In the traditional subscription model of publishing, journals typically require transfer of copyright from authors for articles they publish and their primary revenue stream is through fees charged to readers to access journal content, typically subscription fees or pay-per-article charges. Open access publishing, in contrast, typically allows for authors to retain copyright, and is combined with a license (often from Creative Commons), which enables free and immediate access to published content coupled with rights of reuse (1). Some open access journals (2) and many hybrid journals (i.e., those with some open access content and also with non-open access content) (3) use a business model that relies upon publication charges (often called article publication or processing charges, or APC) to the author or funder of the research to permit immediate and free access.

Predatory publishing is a relatively recent phenomenon that seems to be exploiting some key features of the open access publishing model. It is sustained by collecting APCs that are far less than those found in presumably legitimate open access journals and which are not always apparent to authors prior to article submission. Jeffrey Beall, a librarian at the University of Colorado in Denver, first sounded the alarm about 'predatory journals' and coined the term. He initiated and maintains a listing of journals and publishers that he deems to be potentially, possibly, or probably predatory, called Beall's List (4) (content unavailable at the time of publishing). Their status is determined by a single person (Jeffrey Beall), against a set of evolving criteria (in its 3rd edition at the time of writing) that Beall has based largely on The Committee On Publication Ethics (COPE) Code of Conduct for Journal Editors and membership criteria of the Open Access Scholarly Publisher's Association (5–7). Others have suggested similar criteria for defining predatory journals (8,9).

The phenomenon of predatory publishing is growing and opinions on its effects are divided. Critics say that it is extremely damaging to the scientific record and must be stopped (10,11). Others feel that, while problematic, predatory publishing is a transient state in publishing and will disappear or become obvious over time (12). A fundamental problem of predatory journals seems to be that they collect an APC from authors without offering concomitant scholarly peer review (although many claim to (13)) that is typical of legitimate journals (14). Additionally, they do not appear to provide typical publishing services such as quality control, licensing, indexing, and perpetual content preservation and may not even be fully open access. They tend to solicit manuscripts from authors through repeated email invitations (i.e., spam) boasting open access, rapid peer review, and praising potential authors as experts or opinion leaders (13). These invitations may seem attractive or an easy solution to inexperienced or early career researchers who need to publish in order to advance their career, or to those desperate to get a publication accepted after a number of rejections, or to those simply not paying attention. Predatory journals may also be a particular problem in emerging markets of scientific research, where researchers face the same pressure to publish, but lack the skills and awareness to discern legitimate journals from predatory ones.

Still, many researchers and potential authors are not aware of the problem of predatory journals and may not be able to detect a predatory journal or distinguish one from a legitimate journal. In order to assist readers, potential authors, and others in discerning legitimate journals from predatory journals, it would be useful to compare characteristics from both predatory and non-predatory journals to see how they differ.

Objectives

In this study, we undertook a cross-sectional study comparing the characteristics of three types of biomedical journals, namely [1] potential predatory journals, [2] presumed legitimate, fully open access journals, and [3] presumed legitimate subscription-based biomedical journals that may have open access content (e.g., hybrid).

Methods

Design

This was a cross-sectional study.

Journal identification and selection

We searched for journals on July 10, 2014. For feasibility, only journals with English-language websites were considered for inclusion and we set out to randomly select 100 journals within each comparison group. The following selection procedures were used to identify journals within each comparison group:

- **Potential predatory journals ('Predatory'):** We considered all journals named on Beall's List of single publishers for potential inclusion. We applied the MEDLINE Journal Selection criteria (15): "[Journals] *predominantly devoted to reporting original investigations in the biomedical and health sciences, including research in the basic sciences; clinical trials of therapeutic agents; effectiveness of diagnostic or therapeutic techniques; or studies relating to the behavioural, epidemiological, or educational aspects of medicine.*" Three independent assessors (OM, DM, LS) carried out screening in duplicate. From the identified biomedical journals, a computer-generated random sample of 100 journals was selected for inclusion. Journals that were excluded during data extraction were not replaced.
- **Presumed legitimate fully open-access journals ('Open Access'):** A computer-generated, random sample of 95 journals from those listed on PubMed Central as being full, immediate open access, were included. In addition, five well-established open access journals were purposefully included: *PLOS Medicine*, *PLOS One*, *PLOS Biology*, *BMC Medicine*, and *BMC Biology*.

- **Presumed legitimate subscription-based journals ('Subscription-based'):** A computer-generated, random sample of 100 journals from those listed in the Abridged Index Medicus (AIM) was included. AIM was initiated in 1970 containing a selection of articles from 100 (now 119) English-language journals, as a source of relevant literature for practicing clinicians (16). AIM was used here since all journals in this group were initiated prior to the digital era and presumed to have a maintained a partially or fully subscription-based publishing model [confirmed by us].

For all journals, their names and URLs were automatically obtained during the journal selection process and collected in Microsoft Excel. Screening and data extraction were carried out in the online study management software, Distiller SR (Evidence Partners, Ottawa, Canada). Journals with non-functioning websites at the time of data extraction or verification were excluded and not replaced.

Data extraction process

Data were extracted by a single assessor (OM) between October 2014 and February 2015. An independent audit (done by LS) of a random 10% of the sample showed discrepancies in 34/56 items (61%) on at least one occasion. As such, we proceeded to verify the entire sample by a second assessor. Verification was carried out in April 2015 by one of eight assessors (RB, JC, JG, DM, JR, LS, BJS, LT) with experience and expertise on various aspects of biomedical publishing process. Any disagreements that arose during the verification process were resolved by third party arbitration (by LS or LT). It was not possible to fully blind assessors to study groups due to involvement in the journal selection process (OM, DM, LS).

Data extraction items

Items for which data were extracted were based on a combination of items from Beall's criteria (version 2, December 2012) for determining predatory open-access publishers [6], the COPE Code of Conduct for Journal Publishers (http://publicationethics.org/resources/code-conduct), and the OASPA Membership criteria (http://oaspa.org/membership/membership-criteria/). Data for 56 items were extracted in the following nine categories: aims and scope, journal name and publisher, homepage integrity (look and feel), indexing and impact factor, editors and staff, editorial process and peer review, publication ethics and policies, publication model and copyright, and journal location and contact.

Data analysis

Data were descriptively summarized within each arm. Continuous data were summarized by medians and interquartile range (IQR); dichotomous data were summarized using proportions.

Results

Ninety-three potential predatory journals, 99 open access journals, and 100 subscription-based journals were included in the analysis. The process of journal identification, inclusion, and exclusions within each study group is outlined in Fig. 1; 397 journals were identified as potential predatory journals. After de-duplication and screening for journals publishing biomedical content, 156 journals were identified, from which a random sample of 100 were chosen. Seven journals from the predatory group and one from the legitimate open access group were excluded during data extraction due to non-functional websites. No journal appeared in more than one study group.

There were four unanticipated journal exclusions during data extraction in the presumed legitimate open access and subscription-based groups for which randomly selected replacement journals were used. One journal was listed twice in the open access group and was deemed to be a magazine rather than a scientific journal. Two journals in the subscription-based journal group were deemed to be a magazine and a newsletter, respectively. The decision to exclude and replace these was made post-hoc, by agreement between LS and DM.

Our main findings of journal characteristics for each data extraction category are summarized in Tables 1, 2, 3, 4, 5, 6, 7, 8, and 9.

Homepage and general characteristics

About half of the predatory journals in our sample indicated interest in publishing non-biomedical topics (e.g., agriculture, geography, astronomy, nuclear physics) alongside biomedical topics in the stated scope of the journal and seemed to publish on a larger number of topics than non-predatory journals (Table 1). Predatory journals included pharmacology and toxicology (n=59) in the scope of their journal four and a half times more often than open access journals (n=13) and almost 30 times more than subscription-based journals (n=2).

When we examined the similarity of the journal name to other existing journals (e.g., one or two words different on the first page of Google search results), we found that over half of predatory journals (n=51, 55.84%) had names that were similar to an existing journal compared to only 17 open access journals (17.17%) and 22 subscription-based journals (22.00%) (Table 2). In all study groups, the journal name was well reflected in the website URL. For journals that named a country in the journal title, some journals named a different country in the journal contact information (11/21 (52.38%) predatory; 4/13 (30.77%) open access; 1/31 (3.23%) subscription-based) (Table 3). There was a high prevalence of predatory journals from low or low- to middle-income countries (LMICs) (48/64, 75.00%) compared to open access journals (18/92, 19.56%); none of the subscription-based journals listed LMIC addresses.

We assessed the integrity of the homepage by examining the content for errors (Table 4). Spelling and grammatical errors were more prevalent in predatory journals (n=61, 65.59%) compared to in open access (n=6, 6.06%) and subscription-based journals (n=3, 3.00%). In addition, we found

a higher frequency of distorted or potentially unauthorized image use (e.g., company logos such as Google, MEDLINE, COPE, Crossref) in predatory journals (n=59, 63.44%) versus in open access (*n*=5, 5.05%) and subscription-based journals (*n*=1, 1%). Readers were the main target of language used on subscription-based journal webpages (*n*=58, 58%) but less so in open access (*n*=14, 14.14%) and predatory (*n*=3, 3.23%) journals, where authors (predatory journals) or both authors and readers (open access journals) were the primary target.

Metrics and indexing

Most subscription-based journals indicated having a journal impact factor (assumed 2-year Thomson Reuters JIF unless otherwise indicated) (*n*=80, median 4.275 (IQR 2.469–6.239)) compared to less than half of open access journals (*n*=38, 1.750 (1.330–2.853)) and fewer predatory journals (*n*=21, 2.958 (0.500–3.742)) (Table 5). More than half of predatory journals (*n*=54, 58.06%) and subscription-based journals (*n*=62, 62%) mentioned another journal-level metric, compared to only 16 (16.16%) open access journals. A metric called the Index Copernicus Value was the most common other metric mentioned in 31 predatory journals (33.33%) and in three open access journals (3.03%), followed by the 5-year impact factor (Thomson Reuters) mentioned in two open access journals (2.02%) and 27 subscription-based journals (27.00%), followed by the Scientific Journal Rankings (i.e., SCImago Journal Rank by Scopus) mentioned in seven predatory, six open access, and eight subscription-based journals. The top databases in which journals indicated being indexed were Google Scholar for predatory journals (*n*=47, 50.54%), PubMed for open access journals (*n*=85, 85.86%), and MEDLINE for subscription-based journals (*n*=39, 39%). About half of predatory journals (*n*=48, 51.61%) and 65 (65.65%) open access journals mention DOAJ (indexed in or applied for indexing). International Committee of Medical Journal Editors (ICMJE) was mentioned in some capacity in 16 predatory journals and about three quarters of non-predatory journals.

Editors and editorial process

Nearly a quarter (*n*=22, 23.66%) of predatory journals, 17 (17.17%) open access journals, and 9 (9%) subscription-based journals did not name an editor-in-chief (EIC) (Table 6). Of those that did, 40 (56.33%) predatory, 71 (86.59%) open access, and 57 (62.64%) subscription-based journals provided an institutional affiliation for the named EIC. An editorial board listing individual members was provided in 60 (64.52%) predatory journals, 92 (92.93%) open access journals, and 72 (72%) subscription-based journals, each comprising a median of 23 (IQR 14–37), 32.5 (22–50), and 27.5 (16.5–62) board members, respectively. If editors, journal staff, or editorial board members were identified, we completed a subjective assessment of the validity of three arbitrary names and the likelihood of their association with the journal by performing a Google search of their name (in quotations) and searching any online profiles for affiliation with the journal. Details of this assessment can be found in Table 6. For journals with names of editors, staff, or board members available, 100% of names checked in subscription-based journals were found to be legitimate as well as in 95/98 (96.94%) open access journals. Only 24/90 (26.67%) named editors,

staff, or board members were assessed as having a legitimate association with the journal among predatory journals. Almost 100% of non-predatory journals appear to use a manuscript submission system, whereas just over half of predatory journals use such a system; almost 70% of predatory journals request that authors send their manuscripts by email and 63% of those journals provide what appears to be a non-professional (e.g., Gmail, Yahoo) email address to do so. Almost all journals (95% predatory journals, 100% open access journals, 92% of subscription-based journals) indicate using peer review during publication consideration (Table 7).

Publication ethics and policies

We examined journals' promotion and practices around publications ethics (Table 8). About three quarters (*n* = 77, 77.78%) of open access journals and about a third (*n* = 33, 33.00%) of subscription-based journals mentioned COPE somewhere on their website whereas only 13 predatory journals (13.98%) did. Few predatory journals had policies about retractions (*n* = 12, 12.90%), corrections/errata (*n* = 22, 23.66%), or plagiarism (*n* = 44, 47.31%) whereas more than half of all non-predatory journals had available policies for all three (retractions: *n* = 112, 56.28%; corrections/errata: *n* = 100, 50.25%; plagiarism: *n* = 199, 59.80%). Sixty-two subscription-based (62%), 56 open access (56.57%), and only 6 predatory (6.45%) journals suggested, recommended or required study registration. No predatory journals mentioned the Enhancing the Quality and Transparency of health Research (EQUATOR) Network, whereas about a quarter (49/195) of presumed legitimate journals did so.

Publication model, fees, and copyright

We assessed whether journals made any indication about accessibility, fees, and copyright (Table 9). Forty-two (42.00%) subscription-based journals indicated being partially open access in some capacity (e.g., hybrid or delayed access), with the remainder not mentioning open access. Almost all (*n* = 95, 95.00%) subscription-based journals indicated that there was a subscription charge. Eighty-three potential predatory (89.25%) and 94 open access (94.95%) journals claimed to be open access (presumed to be full, immediate open access as no qualification regarding partial or delayed access was stated). For the five (5.05%) open access journals that did not specifically indicate being open access, all had content that was free to access (we did not investigate this further). Subscription-based journals and open access journals seemed to collect revenue from a range of sources (Table 9), while predatory journals appeared to mainly collect revenues from APCs (*n* = 73, 78.49%) and to a lesser extent, subscription fees (*n* = 13, 13.98); in 14 predatory journals (15.05%), no sources of revenue (including an APC) could be found. Of journals listing an APC, the median fee (USD) was $100 ($63–$150) in predatory journals (*n* = 59), $1866 ($800–$2205) in open access journals (*n* = 70), and $3000 ($2500–$3000) in subscription-based hybrid journals (*n* = 44). Almost 90% of all journals indicated which party retained copyright of published work. Explicit statements that authors retained copyright were present in 68.09% (*n* = 64) of open access journals, 36.78% (*n* = 32) of the time in subscription-based journals, and in only 12% (*n* = 9) of predatory journals.

Discussion

This study demonstrates that our sample of potential predatory journals is distinct in some key areas from presumed legitimate journals and provides evidence of how they differ. While criteria have been proposed previously to characterize potential predatory journals (7), measuring each journal against a long list of criteria is not practical for the average researcher. It can be time consuming and some criteria are not straightforward to apply, as we have learned during this study. For instance, whether or not the listed editors of a journal are real people or have real affiliations with a journal is quite subjective to assess. Another example pertains to preservation and permanent access to electronic journal content. We found that not all presumed legitimate journals made explicit statements about this; however, we know that in order to be indexed in MEDLINE, a journal must "*Have an acceptable arrangement for permanent preservation of, and access to, the content*"(17).

From our findings, we have developed a list of evidence-based, salient features of suspected predatory journals (Table 10) that are straightforward to assess; we describe them further below. We recognize that these criteria are likely not sensitive enough to detect all potentially illegitimate, predatory journals. However, we feel they are a good starting point.

Non-biomedical scope of interest

We found that predatory journals tend to indicate interest in publishing research that was both biomedical and non-biomedical (e.g., agriculture, geography, astrophysics) within their remit, presumably to avoid limiting submissions and increase potential revenues. While legitimate journals may do this periodically (we did not assess the scope of presumed legitimate biomedical journals), the topics usually have some relationship between them and represent a subgroup of a larger medical specialty (e.g., Law and Medicine). Authors should examine the scope and content (e.g., actual research) of the journals they intend to publish in to determine whether it is in line with what they plan to publish.

Spelling and grammar

The home page of a journal's website may be a good initial indicator of their legitimacy. We found several homepage indicators that may be helpful in assessing a journal's legitimacy and quality. The homepages of potential predatory journals' websites contained at least 10 times more spelling and grammar errors than presumed legitimate journals. Such errors may be an artefact of foreign language translation into English, as the majority of predatory journals were based in countries where a non-English language is dominant. Further, legitimate publishers and journals may be more careful about such errors to maintain professionalism and a good reputation.

Fuzzy, distorted, or potentially unauthorized image

Potential predatory journals appeared to have images that were low-resolution (e.g., fuzzy around the edges) or distorted 'knock-off' versions of legitimate logos or images.

Language directed at authors

Another homepage check authors can do is to examine the actual written text to gauge the intended audience. We found that presumed legitimate journals appear to target readers with their language and content (e.g., highlighting new content), whereas potential predatory journals seem to target prospective authors by inviting submissions, promising rapid publication, and promoting different metrics (including the Index Copernicus Value).

Manuscript submission and editorial process/policies

Authors should be able to find information about what happens to their article after it is submitted. Potential predatory journals do not seem to provide much information about their operations compared to presumed legitimate journals. Furthermore, most potential predatory journals request that articles be submitted via email rather than a submission system (e.g., Editorial Manager, Scholar One), as presumed legitimate journals do. Typically, journals have requirements that must be met or checked by authors or the journal during submission (e.g., declaration of conflicts of interest, agreement that the manuscript adheres to authorship standards and other journal policies, plagiarism detection). When a manuscript is submitted via email, these checks are not automatic and may not ever occur. Authors should be cautious of publishing in journals that only take submissions via email and that do not appear to check manuscripts against journal policies as such journals are likely of low quality. In addition, the email address provided by a journal seems to be a good indicator of its legitimacy. Predatory journals seem to provide non-professional or non-academic email addresses such as from providers with non-secured servers like Gmail or Yahoo.

Very low APC and inappropriate copyright

Finally, authors should be cautious when the listed APC of a biomedical journal is under $150 USD. This is very low in comparison to presumed legitimate, fully open access biomedical journals for which the median APC is at least 18 times more. Hybrid subscription journals charge 30 times the amount of potential predatory journals to publish and make research openly accessible. It has been suggested that hybrid journals charge a higher fee in order to maintain their 'prestige' (e.g., journals can be more selective about their content based on who is willing to pay the high fee) (18). On the contrary, extremely low APCs may simply be a way for potential predatory journals to attract as many submissions as possible in order to generate revenue and presumably to build their content and reputation. Evidently, the APC varies widely across journals, perhaps more than any other characteristic we measured. Journal APCs are constantly evolving and increasing

requirements by funders to make research open access may have a drastic impact on APCs as we know them over the coming years.

Researchers should be trained on author responsibilities, including how to make decision about where to publish their research. Ideally, authors should start with a validated or 'white' list of acceptable journals. In addition to considering the items listed in Table 10 in their decision-making, tools to guide authors through the journal selection process have started to emerge, such as "ThinkCheckSubmit" (http://thinkchecksubmit.org/). Recently, COPE, OASPA, DOAJ, and WAME produced principles of transparency against which, among other measures, DOAJ assesses journals in part, before they can be listed in the database (https://doaj.org/bestpractice). We also encourage researchers to examine all journals for quality and legitimacy using the characteristics in Table 10 when making a decision on where to submit their research. As the journal landscape changes, it is no longer sufficient for authors to make assumptions about the quality of journals based on arbitrary measures, such as perceived reputation, impact factor, or other metrics, particularly in an era where bogus metrics abound or legitimate ones are being imitated.

This study examined most of Beall's criteria for identification of predatory publishers and journals together with items from the COPE and OASPA. While many of the characteristics we examined were useful to distinguish predatory journals from presumed legitimate journals, there were many that do not apply or that are not unique to predatory journals. For instance, defining criteria of predatory journals (7) suggest that no single individual is named as an editor and that such journals do not list an editorial board. We found that this was not the case in over two thirds of predatory journals and, in fact, a named EIC could not be identified for 26 (13.07%) of the presumed legitimate journals in our sample. Such non evidence-based criteria for defining journals may introduce confusion rather than clarity and distinction.

The existing designation of journals and publishers as predatory may be confusing for other reasons. For instance, more than one presumed-legitimate publisher has appeared on Beall's list (19). In October 2015, Frontiers Media, a well-known Lausanne-based open access publisher, appeared on Beall's List (20). Small, new, or under-resourced journals may appear to have the look and feel of a potential predatory journal because they do not have affiliations with large publishers or technologies (e.g., manuscript submission systems) or mature systems and the features of a legitimate journal. This is in line with our findings that journals from low-resourced (LMIC) countries were more often in the potentially predatory group of journals than either of the presumed-legitimate journal arms. However, this does not imply that they are necessarily predatory journals.

Another limitation is that the majority of the open access biomedical journals in our sample (95%) charged an APC, while generally many open access journals do not. May 2015 was the last time that the DOAJ provided complete information regarding APCs of journals that it indexes (fully open access, excluding delayed or partial open access). At that time, approximately 32% of journals charged an APC. At the time of writing this article, approximately 40% of medical journals in DOAJ appear to charge an APC. However, these figures do not account for the hybrid-subscription journals that have made accommodations in response to open access, many of which are included in our sample of subscription-based journals. For such journals, our data and that of others (21)

show that their fees appear to be substantially higher than either potential predatory or fully open access journals.

In context of other research

To the best of our knowledge this is the first comparative study of predatory journal publishing and legitimate publishing models aimed at determining how they are different and similar. Previously, Shen and Björk (22) examined a sample of about 5% of journals listed on Beall's List for a number of characteristics, including three that overlap with items for which we collected data: APC, country of publisher, and rapidity of (submission to) publishing (22). In a large part, for the characteristics examined, our findings within the predatory journal group are very similar. For example, Shen and Björk (22) found the average APC for single publisher journals to be $98 USD, which is very similar to our results ($100 USD). They also found that 42% of single predatory journal publishers were located in India, whereas our estimates were closer to 62%. Differences between their study and ours may exist because we focused on biomedical journals while they included all subject areas.

Limitations

It was not possible to fully blind assessors to study groups since, given the expertise of team members, a minimum knowledge of non-predatory publishers was expected. In addition, we could only include items that could be assessed superficially rather than those requiring in-depth investigations for each journal. Many items can and should be investigated further.

Since some characteristics are likely purposely similar between journals (e.g., journals from all groups claim to be open access and indicate carrying out peer review) (14), and it was difficult to anticipate which, we did not carry out a logistic regression to determine whether characteristics were likely to be associated with predatory or presumed legitimate journals.

Conclusions

This research initiates the evidence-base illuminating the difference between major publishing models and, moreover, unique characteristics of potential predatory (or illegitimate) journals (Table 10).

The possibility that some journals are predatory is problematic for many stakeholders involved in research publication. Most researchers are not formally trained on publication skills and ethics, and as such may not be able to discern whether a journal is running legitimate operations or not. For early career researchers or for those who are unaware of the existence or characteristics of predatory journals, they can be difficult to distinguish from legitimate journals. However, this study indicates that predatory journals are offering at least 18-fold lower APCs than non-predatory journals, which may be attractive to uninformed authors and those with limited fiscal resources. Assuming that each journal publishes 100 articles annually, the revenues across all predatory journals would amount to at least a $USD 100 million dollar enterprise. This is a substantial amount

of money being forfeited by authors, and potentially by funders and institutions, for publications that have not received legitimate professional editorial and publishing services, including indexing in databases.

Established researchers should beware of predatory journals as well. There are numerous anecdotes about researchers (even deceased researchers (23)) who have been put on a journal's editorial board or named as an editor, who did not wish to be and who were unable to get their names delisted (24). Aside from this potentially compromising the reputation of an individual that finds him or herself on the board, their affiliation with a potential predatory journal may confer legitimacy to the journal that is not deserved and that has the potential to confuse a naïve reader or author. As our findings indicate, this phenomenon appears to be a clear feature of predatory journals.

In addition to the costs and potential fiscal waste on publication in predatory journals, these journals do not appear to be indexed in appropriate databases to enable future researchers and other readers to consistently identify and access the research published within them. The majority of predatory journals indicated being 'indexed' in Google Scholar, which is not an indexing database. Google does not search pre-selected journals (as is the case with databases such as Medline, Web of Science, and Scopus), rather it searches the Internet for scholarly content. Some potentially predatory journals indicate being indexed in well-known biomedical databases; however, we have not verified the truthfulness of these claims by checking the databases. Nonetheless, if legitimate clinical research is being published in predatory journals and cannot be discovered, this is wasteful (25), in particular when it may impact systematic reviews. Equally, if non-peer reviewed, low quality research in predatory journals is discovered and included in a systematic review, it may pollute the scientific record. In biomedicine, this may have detrimental outcomes on patient care.

Future research

What is contained (i.e., 'published') within potential predatory journals is still unclear. To date, there has not been a large-scale evaluation of the content of predatory journals to determine whether research is being published, what types of studies predominate, and whether or not data (if any) are legitimate. In addition, we have little understanding of who is publishing in predatory journals (i.e., experience of author, geographic location, etc.) and why. Presumably, the low APC is an attractive feature; however, whether or not authors are intentionally or unintentionally publishing within these journals is critical to understanding the publishing landscape and anticipate future potential directions and considerations.

The findings presented here can facilitate education on how to differentiate between presumed legitimate journals and potential predatory journals.

Availability of data and materials

The screening and data extraction forms used, and the data generated, in this study are available from the authors on request.

Tables and Figures

Table 1 Aims and Scope

		Predatory, N = 93, n (%)	Open Access, N = 99, n (%)	Subscription-based, N = 100, n (%)
General research area	Biomedical only	47 (50.53)	99 (100)	100 (100)
	Biomedical & non-biomedical	46 (49.46)	N/A[1]	N/A[1]
Medical subject categories	Top 5 listed (n)	Pharmacology/ Toxicology (59) Research/Laboratory Medicine & Medical Technology (37) Immunology (22) Nursing (18) Dentistry (17)	Research/Laboratory Medicine & Medical Technology (28) Immunology (20) Pharmacology/Toxicology (13) Nursing (12) General and Internal Medicine (12)	General and Internal Medicine (15) Surgery (13) Cardiac & Cardiovascular Systems (12) Public, Environmental & Occupational Health (10) Endocrinology, Metabolism & Nutrition (9)
# of medical categories[a]	median (IQR)	2 (1-4) (range 1-31)	2 (1-2) range (1-23)	1 (1-2) range (1-16)

[1] not assessed; presumed biomedical due to source

[a] Number of journals providing this information: Predatory, n=86; Open Access, n=94; Subscription, n=99;

Table 2 Journal Name and Publisher

		Predatory, N = 93, n (%)	Open Access, N = 99, n (%)	Subscription-based, N = 100, n (%)
Journal name similar to another journal	Yes	51 (54.84)	17 (17.17)	22 (22.00)
Journal URL reflects journal name	Yes	84 (90.32)	95 (95.96)	94 (93.49)
Journal name represents aims & scope[a]	Yes	82 (88.17)	96 (96.97)	95 (95.00)
	No	7 (7.53)	2 (2.02)	1 (1.00)
	Aims/scope not stated	4 (4.30)	1 (1.01)	4 (4.00)
Publisher name indicated	Yes	49 (52.69)	99 (100.00)	98 (98.00)
	No	44 (47.31)	0 (0)	2 (2.00)
Publisher name[b]	Top 5 listed (n)	Laxmi Book Publications (2) All other publishers publish a single journal	BioMed Central (27) Hindawi (14) Medknow (6) Libertas Academica (4) PLOS and OceanSide Publications (3, each)	Elsevier (29) Lippincott Williams & Wilkins (14) BMJ (6) Wiley (6) Oxford University Press (6)
Publisher URL provided[a]	Yes	16/49 (32.65)	86/99 (86.87)	97/98 (98.98)
	No, found using Google	11/33 (33.33)	6/13 (46.15)	0/1 (0.00)
	No, not found on Google	22/33 (66.67)	7/13 (53.87)	1/1 (100.00)
Publisher/owner listed as Editor-in-Chief[c]	Yes	6/37 (16.22)	1/82 (1.22)	0/89 (0)
	No	23/37 (62.16)	81/82 (98.78)	89/89 (100)
	Can't tell	8 /37(21.62)	0/82 (0)	0/89 (0)

[a] Denominator of fractions indicates the number of journals where the variable concerned was relevant

[b] Data presented for journals where publisher was identified

[c] Denominator is the number journals where both publisher and editor-in-chief names were provided

Table 3 Journal Name and Publisher

		Predatory, N = 93, n (%)	Open Access, N = 99, n (%)	Subscription-based, N = 100, n (%)
Country name in journal title differs from country listed in "contact us"[a]	Yes	11/21 (52.38)	4/13 (30.77)	1/31 (3.23)
Country named in contact address[b]	Top 5 listed (n)[*]	India (40) UK (5) USA (4) Romania (3) Bulgaria (2)	UK (34) South Korea (9) Iran (5) New Zealand (4) Germany (3)	USA (66) UK (16) Australia (1) Canada (1) New Zealand (1)
Addresses in low/low-middle income countries (LMIC)[†]		48/64 (75.00%)	18/92 (19.56%)	0/83 (0.00%)
"Contact us" mechanism	Email address	90 (96.77)	91 (91.92)	87 (87.00)
	Fillable web form	42 (45.16)	22 (22.22)	25 (25.00)
	No contact apparent	1 (1.08)	1 (1.01)	7 (7.00)
Non-professional email address provided (e.g. Yahoo, Google, AOL)[c]	Yes	57/90 (63.33)	9/91 (9.89)	5/87 (5.75)
Email address provided for EIC[d]	Yes	39/71 (54.93)	23/82 (28.05)	29/91 (31.87)

[a] Denominator of fraction represents number of journals naming a country in the title
[b] More than one country named by some journals;
[c] Denominator of fractions indicates the number of journals where the variable concerned was relevant
[d] Denominator of fractions indicates the number of journals where an EIC was listed
[*]Number of journals providing this information: Predatory, n=64; Open access n=92; Subscription, n=83
[†] Categorized using 2014 World Bank Data: http://data.worldbank.org/about/country-and-lending-groups

Table 4 Homepage integrity (look and feel)

		Predatory, N = 93, n (%)	Open Access, N = 99, n (%)	Subscription-based, N = 100, n (%)
Presence of spelling & grammatical errors	Yes	61 (65.59)	6 (6.06)	3 (3.00)
Colloquialisms/slang used	Yes	2 (2.15)	1 (1.01)	0 (0)
Presence of distorted/unauthorized images	Yes	59 (63.44)	5 (5.05)	1 (1.00)
Type of user targeted by homepage language	Readers	3 (3.23)	14 (14.14)	58 (58.00)
	Authors	46 (49.46)	13 (13.13)	2 (2.00)
	Both	28 (30.11)	51 (51.51)	26 (26.00)
	Can't Tell	16 (17.20)	21 (21.21)	14 (14.00)

Table 5 Indexing and impact factor

		Predatory, N = 93, n (%)	Open Access, N = 99, n (%)	Subscription-based, N = 100, n (%)
Indicate having Thomson ISI "Journal Impact Factor" (JIF)	Yes	21 (22.58)	38 (38.38)	80 (80.00)
	If yes, median JIF (IQR)*	2.958 (0.500 - 3.742)	1.750 (1.330-2.853)	4.275 (2.469-6.239)
Other journal-level metric indicated	Yes	54 (58.06)	16 (16.16)	62 (62.00)
	# of other metrics, median (IQR)	2 (1-2)	1 (1-2)	1 (1-2)
Other metric	Top 5 listed (n)	Index Copernicus Value (31) Global Impact Factor (9) Scientific Journal Impact Factor (9) Scientific Journal Rankings/SciMago /Scopus (7) Total citations (7)	Scientific Journal Rankings/SciMago /Scopus (6) Total citations (5) Index Copernicus Value (3) h-index (2) 5-year impact factor (2)	5-year impact factor (27) Overall ranking (15) Scientific Journal Rankings/SciMago /Scopus (8) Source Normalized Impact Factor (8) Eigenfactor (7)
Databases indexed/listed	PubMed MEDLINE CINAHL EMBASE PsycInfo Google Scholar Other	6 (6.65) 2 (2.15) 0 (0) 14 (15.05) 0 (0) 47 (50.54) 83 (89.25)	85 (85.86) 21 (21.21) 4 (4.04) 42 (42.42) 7 (7.07) 59 (59.60) 94 (94.95)	17 (17.00) 39 (39.00) 15 (15.00) 32 (32.00) 6 (6.00) 1 (1.00) 55 (55.00)
DOAJ mentioned (indexed or applying for indexing)	Yes	48 (51.61)	65 (65.65)	1 (1.00)
ISSN found/identified	Yes	91 (97.85)	95 (95.96)	72 (72.00)
Editorial Organizations mentioned	ICMJE WAME CSE EASE OASPA Other†	16 (17.2) 4 (4.30) 0 (0) 0 (0) 0 (0) 2 (2.15)	79 (79.8) 8 (8.08) 2 (2.02) 2 (2.02) 6 (6.06) 7 (7.07)	74 (74.00) 14 (14.00) 2 (2.00) 0 (0) 1 (1.00) 3 (3.00)

None	70 (75.27)	10 (10.10)	20 (20.00)

* Number of journals providing this information: Predatory, n=21; Open Access, n=37; Subscription, n=80;

† Other: Association of Learned and Professional Society Publishers, Council of Biology editors, European Medical Writers Association, Higher Attestation Commission of the Russian Ministry of Education and Science, International Association of Scientific, Technical, & Medical Publishers, Korean Association of Medical Journal Editors, OAIster - The Open Access Initiative

Table 6 Editors and staff

		Predatory, N = 93, n (%)	Open Access, N = 99, n (%)	Subscription-based, N = 100, n (%)
Named Editor-in-Chief	Yes	71 (76.34)	82 (82.83)	91 (91.00)
Formal editorial board named	Yes	60 (64.52)	92 (92.93)	72 (72.00)
	If yes, number of members (median, IQR)	23 (14-37)	32.5 (22-50)	27.5 (16.5-62)
Composition of journal staff	Managing/ handling editor	22 (23.66)	18 (18.18)	41 (41.00)
	Associate editor	30 (32.26)	47 (47.47)	68 (68.00)
	Academic editor	0 (0)	0 (0)	1(1.00)
	Statistical editor	2 (2.15)	4 (4.04)	20 (20.00)
	Editorial staff	8 (8.60)	7 (7.07)	19 (19.00)
	Other*	43 (46.24)	45 (45.45)	75 (75.00)
	None of the above	26 (27.96)	24 (24.24)	3 (3.00)
Validity check[a,b]	Legitimate	24/90 (26.67)	95/98 (96.94)	97/97 (100.00)
	False/made up	41/90 (45.56)	2/98 (2.04)	1/97 (1.03)
	Used without permission	66/90 (73.33)	2/98 (2.04)	1/97 (1.03)
Institutional affiliation indicated[b]	Editor-in-Chief	40/71 (56.33)	71/82 (86.59)	57/91 (62.64)
	Editors/ staff	42/67 (62.69)	56/75 (74.67)	48/97 (49.48)
	Editorial board members	48/60 (80.00)	81/92 (88.04)	31/72 (43.06)

* 163 different terms were described, e.g. Editorial office, co-editors, editor(s), deputy editors, acting editor, acting deputy editor, assistant managing editor

[a] Assessors were asked to perform a Google search of the Editor-in-Chief and 2 other randomly selected editors/staff/board members along with their affiliation (if provided) and make a subjective assessment of whether the names appear to be legitimate, false/made up, used without permission. Assessments were based on searches through online profiles [i.e. LinkedIn, faculty bio, etc] for mention of journal affiliation; categories not distinct since judgments based on multiple editors

[b] Denominator of fractions indicates the number of journals where the variable concerned was relevant

Table 7 Editorial process and peer review

		Predatory, N = 93, n (%)	Open Access, N = 99, n (%)	Subscription-based, N = 100, n (%)
Stated manuscript handling process	Yes	53 (56.99)	90 (90.91)	86 (86.00)
Submission system	Third party	2 (2.15)	26 (26.26)	75 (75.00)
	Journal-specific system	47 (50.54)	70 (70.71)	21 (21.00)
	Emailed to journal	65 (69.89)	2 (2.02)	3 (3.00)
	Other*	2 (2.15)	5 (5.05)	0 (0)
	Not found	0 (0)	0 (0)	3 (3.00)
States using peer review	Yes	89 (95.70)	99 (100)	92 (92.00)
Indicated processing time:	"rapid" publication	38 (40.86)	16 (16.16)	9 (9.00)
	<1 week peer review turnaround	17 (18.28)	3 (3.03)	1 (1.00)
	Expedited peer review	9 (9.68)	4 (4.04)	7 (7.00)
	Not indicated	47 (50.54)	84 (84.85)	85 (85.00)

* Other: mailed to journal, publisher-specific system

Table 8 Publication ethics and policies

		Predatory, N = 93, n (%)	Open Access, N = 99, n (%)	Subscription-based, N = 100, n (%)
COPE mentioned	Yes	13 (13.98)	77 (77.78)	33 (33.00)
Publication ethics technologies:	ORCID	2 (2.15)	9 (90.91)	3 (3.00)
	Crossref	10 (10.75)	23 (23.23)	7 (7.00)
	Crossmark	0 (0)	1 (1.01)	2 (2.00)
	Crosscheck/ iThenticate	1 (1.08)	57 (57.58)	16 (16.00)
	none	81 (87.10)	40 (40.40)	77 (77.00)
Retraction policy	Yes	12 (12.90)	44 (44.44)	68 (68.00)
Corrections or errata policy	Yes	22 (23.66)	50 (50.51)	50 (50.00)
Plagiarism policy	Yes	44 (47.31)	70 (70.71)	49 (49.00)
Instructions to Authors available	Yes	90 (96.77)	98 (98.99)	97 (97.00)
If yes, manuscript preparation guidance[a]	Yes	86/90 (95.56)	98/98 (100)	97/97 (100.00)
If yes, reporting guideline(s) mentioned[a]	EQUATOR	0/90 (0.00)	25/98 (25.25)	24/97 (24.00)
	CONSORT	4/90 (4.44)	37/98 (37.76)	57/97 (58.76)
	PRISMA	1/90 (1.11)	26/98 (26.53)	32/97 (32.99)
	STROBE	1/90 (1.11)	27/98 (27.55)	23/97 (23.71)
	STARD	1/90 (1.11)	29/98 (29.59)	22/97 (22.68)
	Other[*]	2/90 (2.22)	30/98 (30.61)	27/97
	None	85/90 (91.40)	54/98 (54.55)	35/97 (35.00)
Study registration required	Yes	6 (6.45)	56(56.57)	62 (62.00)

[a] Denominator of fractions indicates the number of journals where the variable concerned was relevant

[*] 21 other reporting guidelines mentioned, including: ARRIVE, CARE, CHEERS, COREQ, ENTREQ, HuGENet, MIAME, MIBBI, MOOSE, QUOROM, ORION, PRISMA-P, RATS, REDHOT, REFLECT, SPIRIT, SQUIRE, STREGA, TREND, TRIPOD, a custom journal checklist

Table 9 Publication model and copyright

		Predatory, N = 93, n (%)	Open Access, N = 99, n (%)	Subscription-based, N = 100, n (%)
Mentions digital preservation of content	Yes	6 (6.45)	46 (46.46)	30 (30.00)
Claims to be Open Access	Yes	83 (89.25)	94 (94.95)	0 (0)
	No	10 (10.75)	5 (5.05)	39 (39.00)
	Partial (some content)	0	0	42 (42.00)
Number of apparent revenue sources	None apparent	14 (15.05)	8 (8.08)	2 (2.00)
	1	62 (66.67)	52 (50.51)	17 (17.00)
	2	16 (17.20)	27 (27.27)	40 (40.00)
	3	1 (1.08)	7 (7.07)	27 (27.00)
	4	0 (0)	5 (5.05)	14 (14.00)
Type of revenue source	APC	73 (78.49)	74 (74.75)	60 (60.00)
	Submission fee	0 (0)	2 (2.02)	3 (3.00)
	Subscription fee	13 (13.98)	26 (28.28)	95 (95.00)
	Reprints	5 (5.38)	28 (28.28)	42 (42.00)
	Advertisements	3 (3.23)	10 (11.11)	27 (26.00)
	Can't tell	15 (16.13)	8 (8.08)	4 (4.00)
	Other*	3 (3.23)	7 (7.07)	7 (7.00)
APC (USD 04/2015)	Total indicating†	59/73 (80.82)	70/74 (94.59)	44/60 (73.33)
	Amount (Median [IQR])‡	100 (63-150)	1866 (800-2205)	3000 (2500-3000)
	Not stated/found	11 (15.07)	0 (0)	8 (13.11)
	Difficult to find	13 (17.81)	2(2.78)	12 (19.67)
Copyright retention	Total indicating	75 (80.65)	94 (94.95)	87 (87.00)
	Author retains	9 (12.00)	64 (68.09)	32 (36.78)
	Journal/ publisher retains	66 (88.00)	28 (29.79)	54 (62.07)
	Other§	0 (0)	2 (2.02)	1 (1.00)
	Not found/reported	18 (19.35)	5 (5.05)	13 (13.00)
Creative Commons mentioned	Total indicating	22 (23.66)	89 (89.90)	43 (43.00)
	Attribution (CC BY)	12/22 (54.55)	62/89 (69.66)	21/43 (48.84)

	Attribution-ShareAlike (CC BY-SA)	0/22 (0)	1/89 (1.12)	0/43 (0)
	Attribution-NoDerivs (CC BY-ND)	0/22 (0)	1/89 (1.12)	0/43 (0)
	Attribution-NonCommercial (CC BY-NC)	2/22 (9.09)	7/89 (7.87)	17/43 (39.53)
	Attribution-NonCommercial-ShareAlike (CC BY-NC-SA)	4/22 (18.18)	2/89 (2.25)	6/43 (13.95)
	Attribution-NonCommercial-NoDerivs (CC BY-NC-ND)	3/22 (13.64)		30/43 (69.77)
	No specific license indicated	1/22 (4.55)	0 (0)	0 (0)

* Other: per page fee, per author fee, per colour figure fee, and other one-time publication fee
† Denominator of fractions indicates the number of journals where an APC was specifically identified
‡ Data presented for journals indicating an APC
§ Copyright retained by a different journal than the publishing journal (Nigerian Medical Journal)

Table 10 Salient characteristics of potential predatory journals

1.	The scope of interest includes non-biomedical subjects alongside biomedical topics
2.	The website contains spelling and grammar errors
3.	Images are distorted/fuzzy, intended to look like something they are not, or which are unauthorized
4.	The homepage language targets authors
5.	The Index Copernicus Value is promoted on the website
6.	Description of the manuscript handling process is lacking
7.	Manuscripts are requested to be submitted via email
8.	Rapid publication is promised
9.	There is no retraction policy
10.	Information on whether and how journal content will be digitally preserved is absent
11.	The Article processing/publication charge is very low (e.g., < $150 USD)
12.	Journals claiming to be open access either retain copyright of published research or fail to mention copyright
13.	The contact email address is non-professional and non-journal affiliated (e.g., @gmail.com or @yahoo.com)

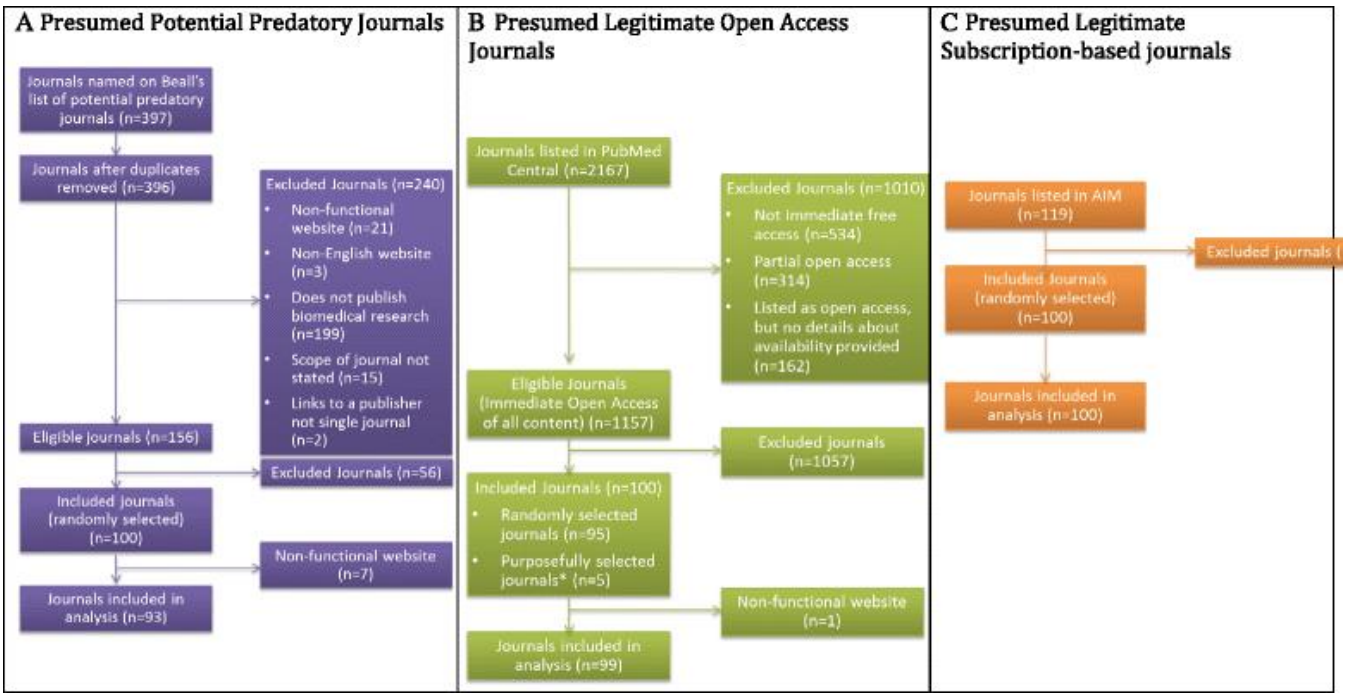


Fig 1.Flow diagram of journal identification, selection, and inclusion in each study group. ***A*** *Potential predatory journals identified from Beall's list.* ***B*** *Presumed legitimate fully open access journals identified from PubMed Central including five purposely selected journals: PLOS Medicine, PLOS One, PLOS Biology, BMC Medicine, and BMC Biology.* ***C*** *Subscription-based journals identified from AIM*

References

1. Bethesda Statement on Open Access Publishing [Internet]. [cited 2016 Mar 31]. Available from: http://legacy.earlham.edu/~peters/fos/bethesda.htm

2. Morrison H, Salhab J, Calvé-Genest A, Horava T. Open Access Article Processing Charges: DOAJ Survey May 2014. Publications. 2015 Feb 5;3(1):1–16.

3. Crotty D. Is it True that Most Open Access Journals Do Not Charge an APC? Sort of. It Depends. [Internet]. The Scholarly Kitchen. 2015 [cited 2016 Apr 4]. Available from: http://scholarlykitchen.sspnet.org/2015/08/26/do-most-oa-journals-not-charge-an-apc-sort-of-it-depends/

4. Beall J. Beall's List: potential, possible, or probable predatory scholarly open-access publishers [Internet]. 2015 [cited 2016 Jan 7]. Available from: http://scholarlyoa.com/publishers/

5. Beall J. Criteria for Determining Predatory Open-Access Publishers. 1st Edition. 2012.

6. Beall J. Criteria for Determining Predatory Open-Access Publishers. 2nd Edition. 2012.

7. Beall J. Criteria for Determining Predatory Open-Access Publishers. 3rd Edition. 2015.

8. Dadkhah M, Bianciardi G. Ranking Predatory Journals: Solve the Problem Instead of Removing It! Adv Pharm Bull. 2016 Mar;6(1):1–4.

9. Glick M, Springer MD, Bohannon J, Bohannon J, Shen C, Björk B-C. Publish and perish. J Am Dent Assoc. 2016 Jun;147(6):385–7.

10. Clark J, Smith R. Firm action needed on predatory journals. BMJ. 2015 Jan 16;350(jan16 1):h210–h210.

11. Caplan AL, Bohannon J, Beall J, Sarwar U, Nicolaou M, Balon R, et al. The Problem of Publication-Pollution Denialism. Mayo Clin Proc. 2015 May;90(5):565–6.

12. Eisen M. Door-to-door subscription scams: the dark side of The New York Times [Internet]. it is NOT junk. 2013 [cited 2016 Jun 22]. Available from: http://www.michaeleisen.org/blog/?p=1354

13. Moher D, Srivastava A. You are invited to submit…. BMC Med. 2015 Dec;13(1):180.

14. Bohannon J. Who's afraid of peer review. Science. 2013;342:60–5.

15. US National Library of Medicine. Fact Sheet MEDLINE® Journal Selection [Internet]. U.S. National Library of Medicine; [cited 2019 Dec 5]. Available from: https://www.nlm.nih.gov/lstrc/jsel.html

16. Committed Selection: Abridged Index Medicus. N Engl J Med. 1970 Jan 22;282(4):220–1.

17. U.S. National Library of Medicine. MEDLINE Policy on Indexing Electronic Journals [Internet]. [cited 2016 Jul 26]. Available from: https://www.nlm.nih.gov/bsd/policy/ejournals.html

18. Van Noorden R. Open access: The true cost of science publishing. Nature. 2013 Mar 27;495(7442):426–9.

19. Butler D. Investigating journals: The dark side of publishing. Nature. 2013 Mar 27;495(7442):433–5.

20. Bloudoff-Indelicato M. Backlash after Frontiers journals added to list of questionable publishers. Nature. 2015 Oct 23;526(7575):613.

21. Wellcome Trust. Wellcome Trust and COAF Open Access Spend, 2014-15 [Internet]. Wellcome Trust blog. 2015 [cited 2016 Jun 21]. Available from: https://blog.wellcome.ac.uk/2016/03/23/wellcome-trust-and-coaf-open-access-spend-2014-15/

22. Shen C, Bjork B-C, Björk B. 'Predatory' open access: a longitudinal study of article volumes and market characteristics. BMC Med. 2015 Dec 1;13(1):230.

23. Spears T. The editor is deceased: Fake science journals hit new low. Ottawa Citizen. 2016 May 11;

24. Kolata G. For Scientists, an Exploding World of Pseudo-Academia. NYTimes.com. 2016 May 11;

25. Chan A-W, Song F, Vickers A, Jefferson T, Dickersin K, Gøtzsche PC, et al. Increasing value and reducing waste: addressing inaccessible research. Lancet. 2014 Jan;383(9913):257–66.

Appendix 1: Author Contributions

DM and LS conceived of this project and drafted the protocol, with revisions by VB. RB, JC, JG, OM, DM, JR, LS, BJS, and LT were involved in the conduct of this project. LS and LT performed analysis of data. LS drafted the manuscript. All authors provided feedback on this manuscript and approved the final version for publication.

Contributor Roles Taxonomy (CRediT)

#	Role	Author(s)	Definition
1	**Conceptualization**	DM, LS	Ideas; formulation or evolution of overarching research goals and aims.
2	**Data curation**	LS	Management activities to annotate (produce metadata), scrub data and maintain research data (including software code, where it is necessary for interpreting the data itself) for initial use and later re-use.
3	**Formal analysis**	LS, LT	Application of statistical, mathematical, computational, or other formal techniques to analyse or synthesize study data.
4	**Funding acquisition**	n/a – not funded	Acquisition of the financial support for the project leading to this publication.
5	**Investigation**	LS, DM, OM, LT, VB, RB, JC, JG, JR, BS	Conducting a research and investigation process, specifically performing the experiments, or data/evidence collection.
6	**Methodology**	LS, DM	Development or design of methodology; creation of models.
7	**Project administration**	LS	Management and coordination responsibility for the research activity planning and execution.

8	**Resources**	DM	Provision of study materials, reagents, materials, patients, laboratory samples, animals, instrumentation, computing resources, or other analysis tools.
9	**Software**	n/a	Programming, software development; designing computer programs; implementation of the computer code and supporting algorithms; testing of existing code components.
10	**Supervision**	LS, DM	Oversight and leadership responsibility for the research activity planning and execution, including mentorship external to the core team.
11	**Validation**	LS	Verification, whether as a part of the activity or separate, of the overall replication/reproducibility of results/experiments and other research outputs.
12	**Visualization**	LS	Preparation, creation and/or presentation of the published work, specifically visualization/data presentation.
13	**Writing – original draft**	LS	Preparation, creation and/or presentation of the published work, specifically writing the initial draft (including substantive translation).
14	**Writing – review & editing**	LS, DM, OM, LT, VB, RB, JC, JG, JR, BS	Preparation, creation and/or presentation of the published work by those from the original research group, specifically critical review, commentary or revision – including pre- or post-publication stages.

Appendix 2: Clarifications to published text

The main text of this chapter is a reproduction of the published text without modification. As such, the following clarifications appended to this thesis are the result of post-publication review by the thesis committee.

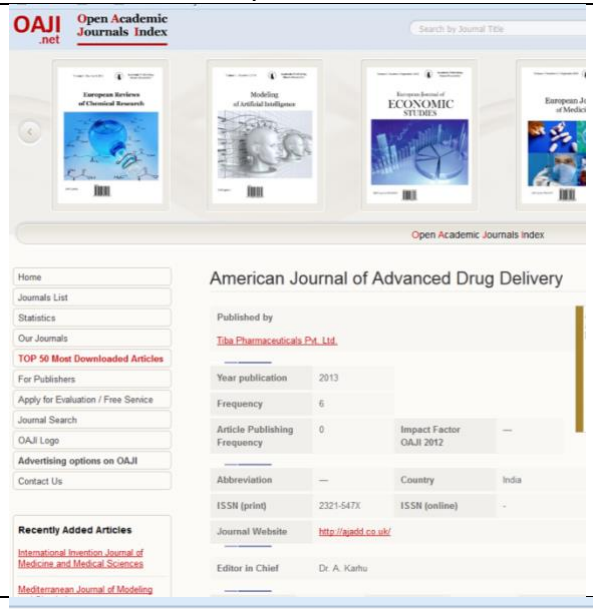
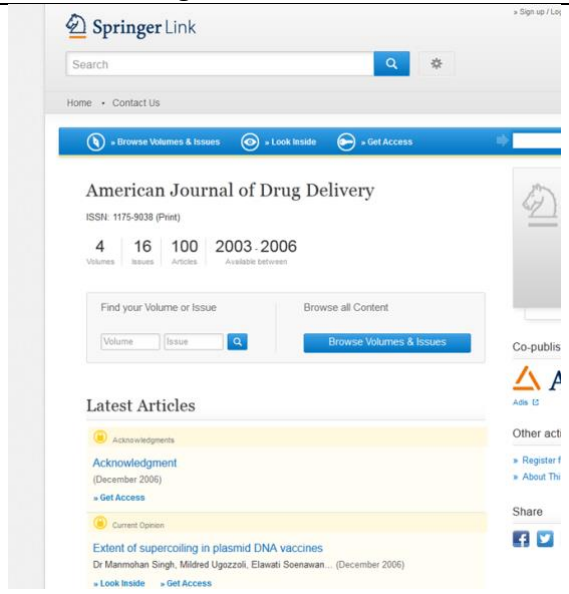
- Jeffrey Beall first documented the term 'predatory journals' in 2008 on his blog Scholarly Open Access. However, the term did not achieve mainstream popularity until after he published about it in *Nature*: Beall, J. Predatory publishers are corrupting open access. *Nature. 2012; 489:*179.
- Jeffery Beall's list of predatory journals and publishers shut down between the time this article was accepted (January 7, 2017) and published (March 16, 2017)
- In the 5th paragraph of the background section, the phrase "emerging markets of scientific research" refers to the following: new areas of research, new investigators, areas of the world with growing research presence
- The reference to "Beall's List of single publishers" refers to one of two of Beall's lists. Both have been collectively referred to as the singular, "Beall's List". The list of single publisher's refers to journals published by a publisher with no other journals in their fleet. Beall referred to these as "standalone" journal.
- In the legitimate open access group for the study, we state that we included "five well-established open access journals". This was guided by experience of the study team with experience in open access publishing (DM and VB). These journals (PLOS Medicine, PLOS One, PLOS Biology, BMC Medicine, and BMC Biology) were selected because they were among the first and largest open access journals in medicine.
- Authors who were involved in the study at its outset (LS, DM, OM, JG, and VB) provided input on the data extraction items for this study. Several authors joined the study team after data extraction had started (RB, JC, JR, BJS, LT) after the protocol was developed.
- There were 4 unanticipated exclusions among study groups during the data extraction process. The decision on how to deal with these was made posthoc and was unrelated to study group: (1) When a journal ceased to exist during the process of data extraction, we recorded this and excluded the journal. (7 predatory, 1 open access). (2) When the website of an included journal was visited that did not have scientific articles, we replaced it with another journal.
- For the assessments of/extraction of information from journals, we did not aim to verify information found on the journal website, on any external websites, other than assessing the legitimacy of editor association with the journal. For instance, if a journal said it was listed in PubMed, we did not verify whether this was true. Our aim was to investigate what journals say they do, rather than what they actually do, which would be an interesting complimentary study. Many journal operations and procedures are not transparent and all data items would not be able to be consistently verified.
- For the analysis, we set out to statistically compare characteristics between groups (using t-test or Chi2 and 95% confidence intervals). At the time we initiated this study, we did not anticipate that some or which characteristics would appear similar between predatory and legitimate journals due to purported attempts of predatory publishers to convey legitimacy (we largely learned of the extent of this phenomenon due to our findings). Further, we did not

plan or carry out and regression analysis to determine which evaluated characteristics appeared in Table 10. These were instead based on frequency, deemed importance by the study team, and potential ease of assessment, as described in the manuscript.

- The publishing journal did not allow any examples to be included in the publication, demonstrating some differences/similarity between study groups. These have been provided in Appendix 3 and are also available on the Open Science Framework as supplementary content to this study: https://osf.io/nxn7g/

Appendix 3: Examples of characteristics in predatory and legitimate journals

Also available at: https://osf.io/s823t/

	Potential Predatory Journal	Presumed Legitimate Journal
Similar Journal Name		
Unauthorized/ distorted image		

Appendix 4: Published Article

Shamseer et al. BMC Medicine (2017) 15:28
DOI 10.1186/s12916-017-0785-9

BMC Medicine

RESEARCH ARTICLE Open Access

Potential predatory and legitimate biomedical journals: can you tell the difference? A cross-sectional comparison

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Abstract

Background: The Internet has transformed scholarly publishing, most notably, by the introduction of open access publishing. Recently, there has been a rise of online journals characterized as 'predatory', which actively solicit manuscripts and charge publications fees without providing robust peer review and editorial services. We carried out a cross-sectional comparison of characteristics of potential predatory, legitimate open access, and legitimate subscription-based biomedical journals.

Methods: On July 10, 2014, scholarly journals from each of the following groups were identified – potential predatory journals (source: Beall's List), presumed legitimate, fully open access journals (source: PubMed Central), and presumed legitimate subscription-based (including hybrid) journals (source: Abridged Index Medicus). MEDLINE journal inclusion criteria were used to screen and identify biomedical journals from within the potential predatory journals group. One hundred journals from each group were randomly selected. Journal characteristics (e.g., website integrity, look and feel, editors and staff, editorial/peer review process, instructions to authors, publication model, copyright and licensing, journal location, and contact) were collected by one assessor and verified by a second. Summary statistics were calculated.

Results: Ninety-three predatory journals, 99 open access, and 100 subscription-based journals were analyzed; exclusions were due to website unavailability. Many more predatory journals' homepages contained spelling errors (61/93, 66%) and distorted or potentially unauthorized images (59/93, 63%) compared to open access journals (6/99, 6% and 5/99, 5%, respectively) and subscription-based journals (3/100, 3% and 1/100, 1%, respectively). Thirty-one (33%) predatory journals promoted a bogus impact metric – the Index Copernicus Value – versus three (3%) open access journals and no subscription-based journals. Nearly three quarters ($n = 66$, 73%) of predatory journals had editors or editorial board members whose affiliation with the journal was unverified versus two (2%) open access journals and one (1%) subscription-based journal in which this was the case. Predatory journals charge a considerably smaller publication fee (median $100 USD, IQR $63–$150) than open access journals ($1865 USD, IQR $800–$2205) and subscription-based hybrid journals ($3000 USD, IQR $2500–$3000).

Conclusions: We identified 13 evidence-based characteristics by which predatory journals may potentially be distinguished from presumed legitimate journals. These may be useful for authors who are assessing journals for possible submission or for others, such as universities evaluating candidates' publications as part of the hiring process.

Keywords: Predatory, Open access, Scientific publishing, Publishing models, Biomedical journal, Journalology

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Background

The Internet has transformed scholarly publishing. It has allowed for the digitalization of content and subsequent online experimentation by publishers, enabling print journals to host content online, and set the course for online open-access publishing. Nevertheless, an unwelcome consequence of the Internet age of publishing has been the rise of so-called predatory publishing.

In the traditional subscription model of publishing, journals typically require transfer of copyright from authors for articles they publish and their primary revenue stream is through fees charged to readers to access journal content, typically subscription fees or pay-per-article charges. Open access publishing, in contrast, typically allows for authors to retain copyright, and is combined with a license (often from Creative Commons), which enables free and immediate access to published content coupled with rights of reuse [1]. Some open access journals [2] and many hybrid journals (i.e., those with some open access content and also with non-open access content) [3] use a business model that relies upon publication charges (often called article publication or processing charges, or APC) to the author or funder of the research to permit immediate and free access.

Predatory publishing is a relatively recent phenomenon that seems to be exploiting some key features of the open access publishing model. It is sustained by collecting APCs that are far less than those found in presumably legitimate open access journals and which are not always apparent to authors prior to article submission. Jeffrey Beall, a librarian at the University of Colorado in Denver, first sounded the alarm about 'predatory journals' and coined the term. He initiated and maintains a listing of journals and publishers that he deems to be potentially, possibly, or probably predatory, called Beall's List [4] (content unavailable at the time of publishing). Their status is determined by a single person (Jeffrey Beall), against a set of evolving criteria (in its 3rd edition at the time of writing) that Beall has based largely on The Committee On Publication Ethics (COPE) Code of Conduct for Journal Editors and membership criteria of the Open Access Scholarly Publisher's Association [5–7]. Others have suggested similar criteria for defining predatory journals [8, 9].

The phenomenon of predatory publishing is growing and opinions on its effects are divided. Critics say that it is extremely damaging to the scientific record and must be stopped [10, 11]. Others feel that, while problematic, predatory publishing is a transient state in publishing and will disappear or become obvious over time [12]. A fundamental problem of predatory journals seems to be that they collect an APC from authors without offering concomitant scholarly peer review (although many claim to [13]) that is typical of legitimate journals [14]. Additionally, they do not appear to provide typical publishing services such as quality control, licensing, indexing, and perpetual content preservation and may not even be fully open access. They tend to solicit manuscripts from authors through repeated email invitations (i.e., spam) boasting open access, rapid peer review, and praising potential authors as experts or opinion leaders [13]. These invitations may seem attractive or an easy solution to inexperienced or early career researchers who need to publish in order to advance their career, or to those desperate to get a publication accepted after a number of rejections, or to those simply not paying attention. Predatory journals may also be a particular problem in emerging markets of scientific research, where researchers face the same pressure to publish, but lack the skills and awareness to discern legitimate journals from predatory ones.

Still, many researchers and potential authors are not aware of the problem of predatory journals and may not be able to detect a predatory journal or distinguish one from a legitimate journal. In order to assist readers, potential authors, and others in discerning legitimate journals from predatory journals, it would be useful to compare characteristics from both predatory and non-predatory journals to see how they differ.

In this study, we undertook a cross-sectional study comparing the characteristics of three types of biomedical journals, namely (1) potential predatory journals, (2) presumed legitimate, fully open access journals, and (3) presumed legitimate subscription-based biomedical journals that may have open access content (e.g., hybrid).

Methods

Design

This was a cross-sectional study.

Journal identification and selection

We searched for journals on July 10, 2014. For feasibility, only journals with English-language websites were considered for inclusion and we set out to randomly select 100 journals within each comparison group. The following selection procedures were used to identify journals within each comparison group:

- *Potential predatory journals ('Predatory'):* We considered all journals named on Beall's List of single publishers for potential inclusion. We applied the MEDLINE Journal Selection criteria [15]: "[Journals] *predominantly devoted to reporting original investigations in the biomedical and health sciences, including research in the basic sciences; clinical trials of therapeutic agents; effectiveness of diagnostic or therapeutic techniques; or studies relating to the behavioural, epidemiological, or educational aspects of medicine.*" Three independent assessors (OM, DM, LS) carried out screening in

duplicate. From the identified biomedical journals, a computer-generated random sample of 100 journals was selected for inclusion. Journals that were excluded during data extraction were not replaced.

- *Presumed legitimate fully open-access journals ('Open Access'):* A computer-generated, random sample of 95 journals from those listed on PubMed Central as being full, immediate open access, were included. In addition, five well-established open access journals were purposefully included: *PLOS Medicine*, *PLOS One*, *PLOS Biology*, *BMC Medicine*, and *BMC Biology*.
- *Presumed legitimate subscription-based journals ('Subscription-based'):* A computer-generated, random sample of 100 journals from those listed in the Abridged Index Medicus (AIM) was included. AIM was initiated in 1970 containing a selection of articles from 100 (now 119) English-language journals, as a source of relevant literature for practicing clinicians [16]. AIM was used here since all journals in this group were initiated prior to the digital era and presumed to have a maintained a partially or fully subscription-based publishing model [confirmed by us].

For all journals, their names and URLs were automatically obtained during the journal selection process and collected in Microsoft Excel. Screening and data extraction were carried out in the online study management software, Distiller SR (Evidence Partners, Ottawa, Canada). Journals with non-functioning websites at the time of data extraction or verification were excluded and not replaced.

Data extraction process

Data were extracted by a single assessor (OM) between October 2014 and February 2015. An independent audit (done by LS) of a random 10% of the sample showed discrepancies in 34/56 items (61%) on at least one occasion. As such, we proceeded to verify the entire sample by a second assessor. Verification was carried out in April 2015 by one of eight assessors (RB, JC, JG, DM, JR, LS, BJS, LT) with experience and expertise on various aspects of biomedical publishing process. Any disagreements that arose during the verification process were resolved by third party arbitration (by LS or LT). It was not possible to fully blind assessors to study groups due to involvement in the journal selection process (OM, DM, LS).

Data extraction items

Items for which data were extracted were based on a combination of items from Beall's criteria (version 2, December 2012) for determining predatory open-access publishers [6], the COPE Code of Conduct for Journal Publishers (http://publicationethics.org/resources/code-conduct), and the OASPA Membership criteria (http://oaspa.org/membership/membership-criteria/). Data for 56 items were extracted in the following nine categories: aims and scope, journal name and publisher, homepage integrity (look and feel), indexing and impact factor, editors and staff, editorial process and peer review, publication ethics and policies, publication model and copyright, and journal location and contact.

Data analysis

Data were descriptively summarized within each arm. Continuous data were summarized by medians and interquartile range (IQR); dichotomous data were summarized using proportions.

Results

Ninety-three potential predatory journals, 99 open access journals, and 100 subscription-based journals were included in the analysis. The process of journal identification, inclusion, and exclusions within each study group is outlined in Fig. 1; 397 journals were identified as potential predatory journals. After de-duplication and screening for journals publishing biomedical content, 156 journals were identified, from which a random sample of 100 were chosen. Seven journals from the predatory group and one from the legitimate open access group were excluded during data extraction due to non-functional websites. No journal appeared in more than one study group.

There were four unanticipated journal exclusions during data extraction in the presumed legitimate open access and subscription-based groups for which randomly selected replacement journals were used. One journal was listed twice in the open access group and was deemed to be a magazine rather than a scientific journal. Two journals in the subscription-based journal group were deemed to be a magazine and a newsletter, respectively. The decision to exclude and replace these was made post-hoc, by agreement between LS and DM.

Our main findings of journal characteristics for each data extraction category are summarized in Tables 1, 2, 3, 4, 5, 6, 7, 8 and 9.

Homepage and general characteristics

About half of the predatory journals in our sample indicated interest in publishing non-biomedical topics (e.g., agriculture, geography, astronomy, nuclear physics) alongside biomedical topics in the stated scope of the journal and seemed to publish on a larger number of topics than non-predatory journals (Table 1). Predatory journals included pharmacology and toxicology ($n = 59$) in the scope of their journal four and a half times more often than open access journals ($n = 13$) and almost 30 times more than subscription-based journals ($n = 2$).

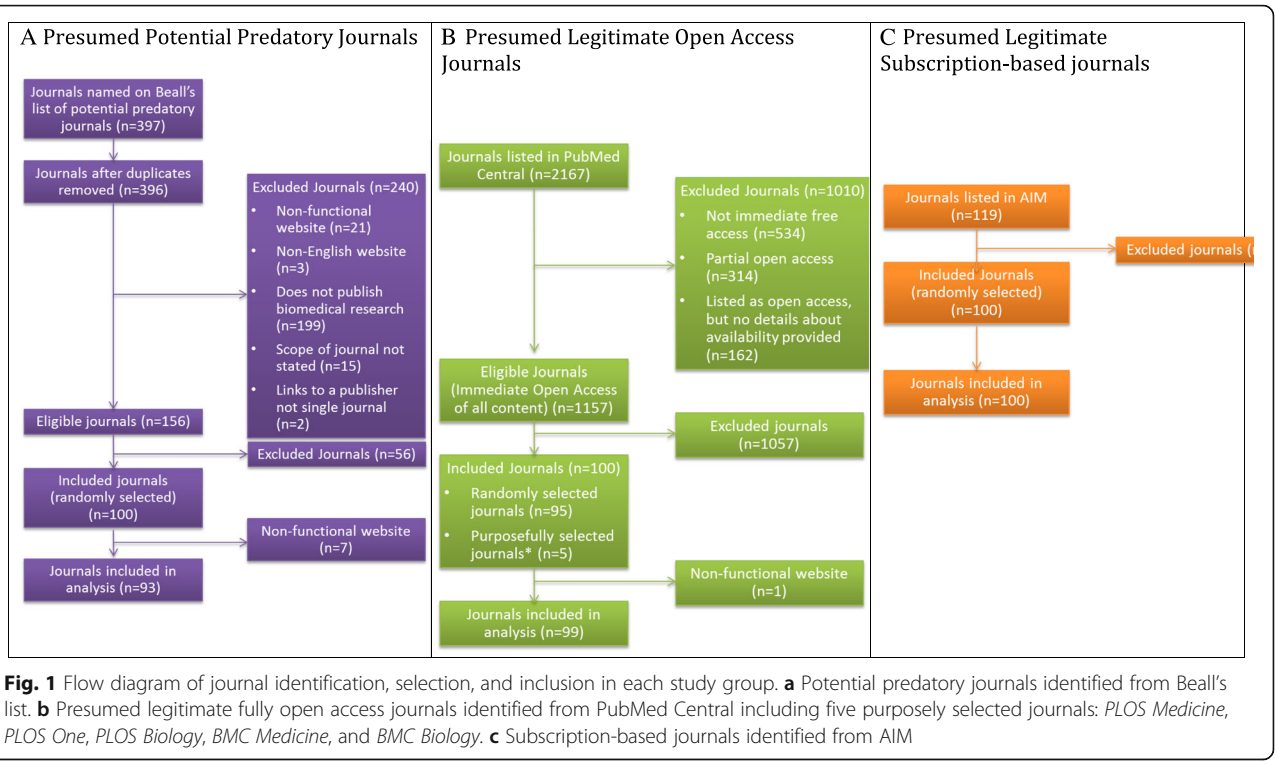

Fig. 1 Flow diagram of journal identification, selection, and inclusion in each study group. **a** Potential predatory journals identified from Beall's list. **b** Presumed legitimate fully open access journals identified from PubMed Central including five purposely selected journals: *PLOS Medicine*, *PLOS One*, *PLOS Biology*, *BMC Medicine*, and *BMC Biology*. **c** Subscription-based journals identified from AIM

When we examined the similarity of the journal name to other existing journals (e.g., one or two words different on the first page of Google search results), we found that over half of predatory journals ($n = 51$, 55.84%) had names that were similar to an existing journal compared to only 17 open access journals (17.17%) and 22 subscription-based journals (22.00%) (Table 2). In all study groups, the journal name was well reflected in the website URL. For journals that named a country in the journal title, some journals named a different country in the journal contact information (11/21 (52.38%) predatory; 4/13 (30.77%) open access; 1/31 (3.23%) subscription-based) (Table 3). There was a high prevalence of predatory journals from low or low- to middle-income countries (LMICs) (48/64, 75.00%) compared to open access journals (18/92, 19.56%); none of the subscription-based journals listed LMIC addresses.

We assessed the integrity of the homepage by examining the content for errors (Table 4). Spelling and grammatical errors were more prevalent in predatory journals ($n = 61$, 65.59%) compared to in open access ($n = 6$, 6.06%) and subscription-based journals ($n = 3$, 3.00%). In addition, we found a higher frequency of distorted or potentially unauthorized image use (e.g., company logos

Table 1 Aims and scope

		Predatory, $N = 93$, n (%)	Open Access, $N = 99$, n (%)	Subscription-based, $N = 100$, n (%)
General research area	Biomedical only	47 (50.53)	99 (100)	100 (100)
	Biomedical & non-biomedical	46 (49.46)	N/A	N/A[a]
Medical subject categories	Top 5 listed (n)	Pharmacology/Toxicology (59) Research/Laboratory Medicine & Medical Technology (37) Immunology (22) Nursing (18) Dentistry (17)	Research/Laboratory Medicine & Medical Technology (28) Immunology (20) Pharmacology/Toxicology (13) Nursing (12) General and Internal Medicine (12)	General and Internal Medicine (15) Surgery (13) Cardiac & Cardiovascular Systems (12) Public, Environmental & Occupational Health (10) Endocrinology, Metabolism & Nutrition (9)
Number of medical categories[b]	Median (IQR)	2 (1–4) (Range 1–31)	2 (1–2) Range (1–23)	1 (1–2) Range (1–16)

[a]Not assessed; presumed biomedical due to source
[b]Number of journals providing this information: Predatory, $n = 86$; Open Access, $n = 94$; Subscription, $n = 99$

Table 2 Journal name and publisher

		Predatory, *N* = 93, *n* (%)	Open Access, *N* = 99, *n* (%)	Subscription-based, *N* = 100, *n* (%)
Journal name similar to another journal	Yes	51 (54.84)	17 (17.17)	22 (22.00)
Journal URL reflects journal name	Yes	84 (90.32)	95 (95.96)	94 (93.49)
Journal name represents aims and scope	Yes	82 (88.17)	96 (96.97)	95 (95.00)
	No	7 (7.53)	2 (2.02)	1 (1.00)
	Aims/scope not stated	4 (4.30)	1 (1.01)	4 (4.00)
Publisher name indicated	Yes	49 (52.69)	99 (100.00)	98 (98.00)
	No	44 (47.31)	0 (0)	2 (2.00)
Publisher name[a]	Top 5 listed (*n*)	Laxmi Book Publications (2) *All other publishers publish a single journal*	BioMed Central (27) Hindawi (14) Medknow (6) Libertas Academica (4) PLOS and OceanSide Publications (3 each)	Elsevier (29) Lippincott Williams & Wilkins (14) BMJ (6) Wiley (6) Oxford University Press (6)
Publisher URL provided[b]	Yes	16/49 (32.65)	86/99 (86.87)	97/98 (98.98)
	No, found using Google	11/33 (33.33)	6/13 (46.15)	0/1 (0.00)
	No, not found on Google	22/33 (66.67)	7/13 (53.87)	1/1 (100.00)
Publisher/owner listed as Editor-in-Chief[c]	Yes	6/37 (16.22)	1/82 (1.22)	0/89 (0)
	No	23/37 (62.16)	81/82 (98.78)	89/89 (100)
	Cannot tell	8/37 (21.62)	0/82 (0)	0/89 (0)

[a]Data presented for journals where publisher was identified
[b]Denominator of fractions indicates the number of journals where the variable concerned was relevant
[c]Denominator is the number journals where both publisher and Editor-in-Chief names were provided

Table 3 Location and contact information

		Predatory, *N* = 93, *n* (%)	Open Access, *N* = 99, *n* (%)	Subscription-based, *N* = 100, *n* (%)
Country name in journal title differs from country listed in 'contact us'[a]	Yes	11/21 (52.38)	4/13 (30.77)	1/31 (3.23)
Country named in contact address[b]	Top 5 listed (*n*)[e]	India (40) UK (5) USA (4) Romania (3) Bulgaria (2)	UK (34) South Korea (9) Iran (5) New Zealand (4) Germany (3)	USA (66) UK (16) Australia (1) Canada (1) New Zealand (1)
Addresses in low/low- to middle-income countries[f]		48/64 (75.00%)	18/92 (19.56%)	0/83 (0.00%)
'Contact us' mechanism	Email address	90 (96.77)	91 (91.92)	87 (87.00)
	Fillable web form	42 (45.16)	22 (22.22)	25 (25.00)
	No contact apparent	1 (1.08)	1 (1.01)	7 (7.00)
Non-professional email address provided (e.g., Yahoo, Google, AOL)[c]	Yes	57/90 (63.33)	9/91 (9.89)	5/87 (5.75)
Email address provided for Editor-in-Chief[d]	Yes	39/71 (54.93)	23/82 (28.05)	29/91 (31.87)

[a]Denominator of fraction represents number of journals naming a country in the title
[b]More than one country named by some journals
[c]Denominator of fractions indicates the number of journals where the variable concerned was relevant
[d]Denominator of fractions indicates the number of journals where an Editor-in-Chief was listed
[e]Number of journals providing this information: Predatory, *n* = 64; Open access *n* = 92; Subscription, *n* = 83
[f]Categorized using 2014 World Bank Data: http://data.worldbank.org/about/country-and-lending-groups

Table 4 Homepage integrity (look and feel)

		Predatory, $N = 93$, n (%)	Open Access, $N = 99$, n (%)	Subscription-based, $N = 100$, n (%)
Presence of spelling and grammatical errors	Yes	61 (65.59)	6 (6.06)	3 (3.00)
Colloquialisms/slang used	Yes	2 (2.15)	1 (1.01)	0 (0)
Presence of distorted/unauthorized images	Yes	59 (63.44)	5 (5.05)	1 (1.00)
Type of user targeted by homepage language	Readers	3 (3.23)	14 (14.14)	58 (58.00)
	Authors	46 (49.46)	13 (13.13)	2 (2.00)
	Both	28 (30.11)	51 (51.51)	26 (26.00)
	Cannot tell	16 (17.20)	21 (21.21)	14 (14.00)

such as Google, MEDLINE, COPE, Crossref) in predatory journals (n = 59, 63.44%) versus in open access (n = 5, 5.05%) and subscription-based journals (n = 1, 1%). Readers were the main target of language used on subscription-based journal webpages (n = 58, 58%) but less so in open access (n = 14, 14.14%) and predatory (n = 3, 3.23%) journals, where authors (predatory journals) or both authors and readers (open access journals) were the primary target.

Metrics and indexing

Most subscription-based journals indicated having a journal impact factor (assumed 2-year Thomson Reuters JIF unless otherwise indicated) (n = 80, median 4.275 (IQR 2.469–6.239)) compared to less than half of open access journals (n = 38, 1.750 (1.330–2.853)) and fewer predatory journals (n = 21, 2.958 (0.500–3.742)) (Table 5). More than half of predatory journals (n = 54, 58.06%) and subscription-based journals (n = 62, 62%) mentioned

Table 5 Indexing and impact factor

		Predatory, $N = 93$, n (%)	Open Access, $N = 99$, n (%)	Subscription-based, $N = 100$, n (%)
Indicate having Thomson ISI 'Journal Impact Factor' (JIF)	Yes	21 (22.58)	38 (38.38)	80 (80.00)
	If yes, median JIF (IQR)[a]	2.958 (0.500–3.742)	1.750 (1.330–2.853)	4.275 (2.469–6.239)
Other journal-level metric indicated	Yes	54 (58.06)	16 (16.16)	62 (62.00)
	Number of other metrics, median (IQR)	2 (1–2)	1 (1–2)	1 (1–2)
Other metric	Top 5 listed (n)	Index Copernicus Value (31) Global Impact Factor (9) Scientific Journal Impact Factor (9) Scientific Journal Rankings/ SciMago/Scopus (7) Total citations (7)	Scientific Journal Rankings/ SciMago/Scopus (6) Total citations (5) Index Copernicus Value (3) h-index (2) 5-year impact factor (2)	5-year impact factor (27) Overall ranking (15) Scientific Journal Rankings/ SciMago/Scopus (8) Source Normalized Impact Factor (8) Eigenfactor (7)
Databases indexed/listed	PubMed	6 (6.65)	85 (85.86)	17 (17.00)
	MEDLINE	2 (2.15)	21 (21.21)	39 (39.00)
	CINAHL	0 (0)	4 (4.04)	15 (15.00)
	EMBASE	14 (15.05)	42 (42.42)	32 (32.00)
	PsycInfo	0 (0)	7 (7.07)	6 (6.00)
	Google Scholar	47 (50.54)	59 (59.60)	1 (1.00)
	Other	83 (89.25)	94 (94.95)	55 (55.00)
DOAJ mentioned (indexed or applying for indexing)	Yes	48 (51.61)	65 (65.65)	1 (1.00)
ISSN found/identified	Yes	91 (97.85)	95 (95.96)	72 (72.00)
Editorial organizations mentioned	ICMJE	16 (17.2)	79 (79.8)	74 (74.00)
	WAME	4 (4.30)	8 (8.08)	14 (14.00)
	CSE	0 (0)	2 (2.02)	2 (2.00)
	EASE	0 (0)	2 (2.02)	0 (0)
	OASPA	0 (0)	6 (6.06)	1 (1.00)
	Other[b]	2 (2.15)	7 (7.07)	3 (3.00)
	None	70 (75.27)	10 (10.10)	20 (20.00)

ICMJE International Committee of Medical Journal Editors, *WAME* World Association of Medical Editors, *CSE* Council of Science Editors, *EASE* European Association of Science Editors
[a]Number of journals providing this information: Predatory, n = 21; Open Access, n = 37; Subscription, n = 80
[b]Other: Association of Learned and Professional Society Publishers, Council of Biology editors, European Medical Writers Association, Higher Attestation Commission of the Russian Ministry of Education and Science, International Association of Scientific, Technical, & Medical Publishers, Korean Association of Medical Journal Editors, OAIster - The Open Access Initiative

Table 6 Editors and staff

		Predatory, *N* = 93, *n* (%)	Open Access, *N* = 99, *n* (%)	Subscription-based, *N* = 100, *n* (%)
Named Editor-in-Chief	Yes	71 (76.34)	82 (82.83)	91 (91.00)
Formal editorial board named	Yes	60 (64.52)	92 (92.93)	72 (72.00)
	If yes, number of members (median, IQR)	23 (14–37)	32.5 (22–50)	27.5 (16.5–62)
Composition of journal staff	Managing/handling editor	22 (23.66)	18 (18.18)	41 (41.00)
	Associate editor	30 (32.26)	47 (47.47)	68 (68.00)
	Academic editor	0 (0)	0 (0)	1(1.00)
	Statistical editor	2 (2.15)	4 (4.04)	20 (20.00)
	Editorial staff	8 (8.60)	7 (7.07)	19 (19.00)
	Other[a]	43 (46.24)	45 (45.45)	75 (75.00)
	None of the above	26 (27.96)	24 (24.24)	3 (3.00)
Validity check[b,c]	Legitimate	24/90 (26.67)	95/98 (96.94)	97/97 (100.00)
	False/made up	41/90 (45.56)	2/98 (2.04)	1/97 (1.03)
	Used without permission	66/90 (73.33)	2/98 (2.04)	1/97 (1.03)
Institutional affiliation indicated[c]	Editor-in-Chief	40/71 (56.33)	71/82 (86.59)	57/91 (62.64)
	Editors/staff	42/67 (62.69)	56/75 (74.67)	48/97 (49.48)
	Editorial board members	48/60 (80.00)	81/92 (88.04)	31/72 (43.06)

[a]163 different terms were described, e.g., Editorial office, co-editors, editor(s), deputy editors, acting editor, acting deputy editor, assistant managing editor
[b]Assessors were asked to perform a Google search of the Editor-in-Chief and two other randomly selected editors/staff/board members along with their affiliation (if provided) and make a subjective assessment of whether the names appear to be legitimate, false/made up, used without permission. Assessments were based on searches through online profiles (i.e., LinkedIn, faculty bio, etc.) for mention of journal affiliation; categories not distinct since judgments based on multiple editors
[c]Denominator of fractions indicates the number of journals where the variable concerned was relevant

another journal-level metric, compared to only 16 (16.16%) open access journals. A metric called the Index Copernicus Value was the most common other metric mentioned in 31 predatory journals (33.33%) and in three open access journals (3.03%), followed by the 5-year impact factor (Thomson Reuters) mentioned in two open access journals (2.02%) and 27 subscription-based journals (27.00%), followed by the Scientific Journal Rankings (i.e., SCImago Journal Rank by Scopus) mentioned in seven predatory, six open access, and eight subscription-based journals. The top databases in which journals indicated being indexed were Google Scholar for predatory journals ($n = 47$, 50.54%), PubMed for open access journals ($n = 85$, 85.86%), and MEDLINE for subscription-based journals ($n = 39$, 39%). About half of predatory journals ($n = 48$, 51.61%) and 65 (65.65%) open access journals mention DOAJ (indexed in or applied for indexing). International Committee of Medical Journal

Table 7 Editorial process and peer review

		Predatory, *N* = 93, *n* (%)	Open Access, *N* = 99, *n* (%)	Subscription-based, *N* = 100, *n* (%)
Stated manuscript handling process	Yes	53 (56.99)	90 (90.91)	86 (86.00)
Submission system	Third party	2 (2.15)	26 (26.26)	75 (75.00)
	Journal-specific system	47 (50.54)	70 (70.71)	21 (21.00)
	Emailed to journal	65 (69.89)	2 (2.02)	3 (3.00)
	Other[a]	2 (2.15)	5 (5.05)	0 (0)
	Not found	0 (0)	0 (0)	3 (3.00)
States using peer review	Yes	89 (95.70)	99 (100)	92 (92.00)
Indicated processing time	'Rapid' publication	38 (40.86)	16 (16.16)	9 (9.00)
	<1 week peer review turnaround	17 (18.28)	3 (3.03)	1 (1.00)
	Expedited peer review	9 (9.68)	4 (4.04)	7 (7.00)
	Not indicated	47 (50.54)	84 (84.85)	85 (85.00)

[a]Other: mailed to journal, publisher-specific system

Table 8 Publication ethics and policies

		Predatory, *N* = 93, *n* (%)	Open Access, *N* = 99, *n* (%)	Subscription-based, *N* = 100, *n* (%)
COPE mentioned	Yes	13 (13.98)	77 (77.78)	33 (33.00)
Publication ethics technologies:	ORCID	2 (2.15)	9 (90.91)	3 (3.00)
	Crossref	10 (10.75)	23 (23.23)	7 (7.00)
	Crossmark	0 (0)	1 (1.01)	2 (2.00)
	Crosscheck/iThenticate	1 (1.08)	57 (57.58)	16 (16.00)
	none	81 (87.10)	40 (40.40)	77 (77.00)
Retraction policy	Yes	12 (12.90)	44 (44.44)	68 (68.00)
Corrections or errata policy	Yes	22 (23.66)	50 (50.51)	50 (50.00)
Plagiarism policy	Yes	44 (47.31)	70 (70.71)	49 (49.00)
Instructions to authors available	Yes	90 (96.77)	98 (98.99)	97 (97.00)
If yes, manuscript preparation guidance[a]	Yes	86/90 (95.56)	98/98 (100)	97/97 (100.00)
If yes, reporting guideline(s) mentioned[a]	EQUATOR	0/90 (0.00)	25/98 (25.25)	24/97 (24.00)
	CONSORT	4/90 (4.44)	37/98 (37.76)	57/97 (58.76)
	PRISMA	1/90 (1.11)	26/98 (26.53)	32/97 (32.99)
	STROBE	1/90 (1.11)	27/98 (27.55)	23/97 (23.71)
	STARD	1/90 (1.11)	29/98 (29.59)	22/97 (22.68)
	Other[b]	2/90 (2.22)	30/98 (30.61)	27/97
	None	85/90 (91.40)	54/98 (54.55)	35/97 (35.00)
Study registration required	Yes	6 (6.45)	56 (56.57)	62 (62.00)

ORCID Open Researcher and Contributor ID
[a]Denominator of fractions indicates the number of journals where the variable concerned was relevant
[b]21 other reporting guidelines mentioned, including ARRIVE, CARE, CHEERS, COREQ, ENTREQ, HuGENet, MIAME, MIBBI, MOOSE, QUOROM, ORION, PRISMA-P, RATS, REDHOT, REFLECT, SPIRIT, SQUIRE, STREGA, TREND, TRIPOD, a custom journal checklist

Editors (ICMJE) was mentioned in some capacity in 16 predatory journals and about three quarters of non-predatory journals.

Editors and editorial process

Nearly a quarter ($n = 22$, 23.66%) of predatory journals, 17 (17.17%) open access journals, and 9 (9%) subscription-based journals did not name an editor-in-chief (EIC) (Table 6). Of those that did, 40 (56.33%) predatory, 71 (86.59%) open access, and 57 (62.64%) subscription-based journals provided an institutional affiliation for the named EIC. An editorial board listing individual members was provided in 60 (64.52%) predatory journals, 92 (92.93%) open access journals, and 72 (72%) subscription-based journals, each comprising a median of 23 (IQR 14–37), 32.5 (22–50), and 27.5 (16.5–62) board members, respectively. If editors, journal staff, or editorial board members were identified, we completed a subjective assessment of the validity of three arbitrary names and the likelihood of their association with the journal by performing a Google search of their name (in quotations) and searching any online profiles for affiliation with the journal. Details of this assessment can be found in Table 6. For journals with names of editors, staff, or board members available, 100% of names checked in subscription-based journals were found to be legitimate as well as in 95/98 (96.94%) open access journals. Only 24/90 (26.67%) named editors, staff, or board members were assessed as having a legitimate association with the journal among predatory journals. Almost 100% of non-predatory journals appear to use a manuscript submission system, whereas just over half of predatory journals use such a system; almost 70% of predatory journals request that authors send their manuscripts by email and 63% of those journals provide what appears to be a non-professional (e.g., Gmail, Yahoo) email address to do so. Almost all journals (95% predatory journals, 100% open access journals, 92% of subscription-based journals) indicate using peer review during publication consideration (Table 7).

Publication ethics and policies

We examined journals' promotion and practices around publications ethics (Table 8). About three quarters ($n = 77$, 77.78%) of open access journals and about a third ($n = 33$, 33.00%) of subscription-based journals mentioned COPE somewhere on their website whereas only 13 predatory journals (13.98%) did. Few predatory journals had policies about retractions ($n = 12$, 12.90%), corrections/errata ($n = 22$, 23.66%), or plagiarism ($n = 44$, 47.31%) whereas more than half of all non-predatory journals had available policies for

Table 9 Publication model and copyright

		Predatory, $N = 93$, n (%)	Open Access, $N = 99$, n (%)	Subscription-based, $N = 100$, n (%)
Mentions digital preservation of content	Yes	6 (6.45)	46 (46.46)	30 (30.00)
Claims to be Open Access	Yes	83 (89.25)	94 (94.95)	0 (0)
	No	10 (10.75)	5 (5.05)	39 (39.00)
	Partial (some content)	0	0	42 (42.00)
Number of apparent revenue sources	None apparent	14 (15.05)	8 (8.08)	2 (2.00)
	1	62 (66.67)	52 (50.51)	17 (17.00)
	2	16 (17.20)	27 (27.27)	40 (40.00)
	3	1 (1.08)	7 (7.07)	27 (27.00)
	4	0 (0)	5 (5.05)	14 (14.00)
Type of revenue source	Article processing charge	73 (78.49)	74 (74.75)	60 (60.00)
	Submission fee	0 (0)	2 (2.02)	3 (3.00)
	Subscription fee	13 (13.98)	26 (28.28)	95 (95.00)
	Reprints	5 (5.38)	28 (28.28)	42 (42.00)
	Advertisements	3 (3.23)	10 (11.11)	27 (26.00)
	Cannot tell	15 (16.13)	8 (8.08)	4 (4.00)
	Other[a]	3 (3.23)	7 (7.07)	7 (7.00)
APC (USD 04/2015)	Total indicating[b]	59/73 (80.82)	70/74 (94.59)	44/60 (73.33)
	Amount (Median [IQR])[c]	100 (63–150)	1866 (800–2205)	3000 (2500–3000)
	Not stated/found	11 (15.07)	0 (0)	8 (13.11)
	Difficult to find	13 (17.81)	2(2.78)	12 (19.67)
Copyright retention	Total indicating	75 (80.65)	94 (94.95)	87 (87.00)
	Author retains	9 (12.00)	64 (68.09)	32 (36.78)
	Journal/publisher retains	66 (88.00)	28 (29.79)	54 (62.07)
	Other	0 (0)	2 (2.02)	1 (1.00)
	Not found/reported	18 (19.35)	5 (5.05)	13 (13.00)
Creative Commons mentioned	Total indicating	22 (23.66)	89 (89.90)	43 (43.00)
	Attribution (CC BY)	12/22 (54.55)	62/89 (69.66)	21/43 (48.84)
	Attribution-ShareAlike (CC BY-SA)	0/22 (0)	1/89 (1.12)	0/43 (0)
	Attribution-NoDerivs (CC BY-ND)	0/22 (0)	1/89 (1.12)	0/43 (0)
	Attribution-Non-Commercial (CC BY-NC)	2/22 (9.09)	19/89 (21.35)	17/43 (39.53)
	Attribution-Non-Commercial-ShareAlike (CC BY-NC-SA)	4/22 (18.18)	7/89 (7.87)	6/43 (13.95)
	Attribution-Non-Commercial-NoDerivs (CC BY-NC-ND)	3/22 (13.64)	2/89 (2.25)	30/43 (69.77)
	No specific license indicated	1/22 (4.55)	0 (0)	0 (0)

[a]Other: per page fee, per author fee, per colour figure fee, and other one-time publication fee
[b]Denominator of fractions indicates the number of journals where an article processing charge (APC) was specifically identified
[c]Data presented for journals indicating an APC

all three (retractions: $n = 112$, 56.28%; corrections/errata: $n = 100$, 50.25%; plagiarism: $n = 199$, 59.80%). Sixty-two subscription-based (62%), 56 open access (56.57%), and only 6 predatory (6.45%) journals suggested, recommended or required study registration. No predatory journals mentioned the Enhancing the Quality and Transparency of health Research (EQUATOR) Network, whereas about a quarter (49/195) of presumed legitimate journals did so.

Publication model, fees, and copyright

We assessed whether journals made any indication about accessibility, fees, and copyright (Table 9). Forty-

two (42.00%) subscription-based journals indicated being partially open access in some capacity (e.g., hybrid or delayed access), with the remainder not mentioning open access. Almost all ($n = 95$, 95.00%) subscription-based journals indicated that there was a subscription charge. Eighty-three potential predatory (89.25%) and 94 open access (94.95%) journals claimed to be open access (presumed to be full, immediate open access as no qualification regarding partial or delayed access was stated). For the five (5.05%) open access journals that did not specifically indicate being open access, all had content that was free to access (we did not investigate this further). Subscription-based journals and open access journals seemed to collect revenue from a range of sources (Table 9), while predatory journals appeared to mainly collect revenues from APCs ($n = 73$, 78.49%) and to a lesser extent, subscription fees ($n = 13$, 13.98); in 14 predatory journals (15.05%), no sources of revenue (including an APC) could be found. Of journals listing an APC, the median fee (USD) was $100 ($63–$150) in predatory journals ($n = 59$), $1866 ($800–$2205) in open access journals ($n = 70$), and $3000 ($2500–$3000) in subscription-based hybrid journals ($n = 44$). Almost 90% of all journals indicated which party retained copyright of published work. Explicit statements that authors retained copyright were present in 68.09% ($n = 64$) of open access journals, 36.78% ($n2 = 32$) of the time in subscription-based journals, and in only 12% ($n = 9$) of predatory journals.

Discussion

This study demonstrates that our sample of potential predatory journals is distinct in some key areas from presumed legitimate journals and provides evidence of how they differ. While criteria have been proposed previously to characterize potential predatory journals [7], measuring each journal against a long list of criteria is not practical for the average researcher. It can be time consuming and some criteria are not straightforward to apply, as we have learned during this study. For instance, whether or not the listed editors of a journal are real people or have real affiliations with a journal is quite subjective to assess. Another example pertains to preservation and permanent access to electronic journal content. We found that not all presumed legitimate journals made explicit statements about this; however, we know that in order to be indexed in MEDLINE, a journal must "*Have an acceptable arrangement for permanent preservation of, and access to, the content*" [17].

From our findings, we have developed a list of evidence-based, salient features of suspected predatory journals (Table 10) that are straightforward to assess; we describe them further below. We recognize that these criteria are likely not sensitive enough to detect all potentially illegitimate, predatory journals. However, we feel they are a good starting point.

Non-biomedical scope of interest

We found that predatory journals tend to indicate interest in publishing research that was both biomedical and non-biomedical (e.g., agriculture, geography, astrophysics) within their remit, presumably to avoid limiting submissions and increase potential revenues. While legitimate journals may do this periodically (we did not assess the scope of presumed legitimate biomedical journals), the topics usually have some relationship between them and represent a subgroup of a larger medical specialty (e.g., Law and Medicine). Authors should examine the scope and content (e.g., actual research) of the journals they intend to publish in to determine whether it is in line with what they plan to publish.

Spelling and grammar

The home page of a journal's website may be a good initial indicator of their legitimacy. We found several homepage indicators that may be helpful in assessing a journal's legitimacy and quality. The homepages of potential predatory journals' websites contained at least 10 times more spelling and grammar errors than presumed legitimate journals. Such errors may be an artefact of foreign language translation into English, as the majority of predatory journals were based in countries where a non-English language is dominant. Further, legitimate publishers and journals may be more careful about such errors to maintain professionalism and a good reputation.

Fuzzy, distorted, or potentially unauthorized image

Potential predatory journals appeared to have images that were low-resolution (e.g., fuzzy around the edges) or distorted 'knock-off' versions of legitimate logos or images.

Language directed at authors

Another homepage check authors can do is to examine the actual written text to gauge the intended audience. We found that presumed legitimate journals appear to target readers with their language and content (e.g., highlighting new content), whereas potential predatory journals seem to target prospective authors by inviting submissions, promising rapid publication, and promoting different metrics (including the Index Copernicus Value).

Manuscript submission and editorial process/policies

Authors should be able to find information about what happens to their article after it is submitted. Potential predatory journals do not seem to provide much information about their operations compared to presumed legitimate journals. Furthermore, most potential predatory

Table 10 Salient characteristics of potential predatory journals

1.	The scope of interest includes non-biomedical subjects alongside biomedical topics
2.	The website contains spelling and grammar errors
3.	Images are distorted/fuzzy, intended to look like something they are not, or which are unauthorized
4.	The homepage language targets authors
5.	The Index Copernicus Value is promoted on the website
6.	Description of the manuscript handling process is lacking
7.	Manuscripts are requested to be submitted via email
8.	Rapid publication is promised
9.	There is no retraction policy
10.	Information on whether and how journal content will be digitally preserved is absent
11.	The Article processing/publication charge is very low (e.g., < $150 USD)
12.	Journals claiming to be open access either retain copyright of published research or fail to mention copyright
13.	The contact email address is non-professional and non-journal affiliated (e.g., @gmail.com or @yahoo.com)

journals request that articles be submitted via email rather than a submission system (e.g., Editorial Manager, Scholar One), as presumed legitimate journals do. Typically, journals have requirements that must be met or checked by authors or the journal during submission (e.g., declaration of conflicts of interest, agreement that the manuscript adheres to authorship standards and other journal policies, plagiarism detection). When a manuscript is submitted via email, these checks are not automatic and may not ever occur. Authors should be cautious of publishing in journals that only take submissions via email and that do not appear to check manuscripts against journal policies as such journals are likely of low quality. In addition, the email address provided by a journal seems to be a good indicator of its legitimacy. Predatory journals seem to provide non-professional or non-academic email addresses such as from providers with non-secured servers like Gmail or Yahoo.

Very low APC and inappropriate copyright

Finally, authors should be cautious when the listed APC of a biomedical journal is under $150 USD. This is very low in comparison to presumed legitimate, fully open access biomedical journals for which the median APC is at least 18 times more. Hybrid subscription journals charge 30 times the amount of potential predatory journals to publish and make research openly accessible. It has been suggested that hybrid journals charge a higher fee in order to maintain their 'prestige' (e.g., journals can be more selective about their content based on who is willing to pay the high fee) [18]. On the contrary, extremely low APCs may simply be a way for potential predatory journals to attract as many submissions as possible in order to generate revenue and presumably to build their content and reputation. Evidently, the APC varies widely across journals, perhaps more than any other characteristic we measured. Journal APCs are constantly evolving and increasing requirements by funders to make research open access may have a drastic impact on APCs as we know them over the coming years.

Researchers should be trained on author responsibilities, including how to make decision about where to publish their research. Ideally, authors should start with a validated or 'white' list of acceptable journals. In addition to considering the items listed in Table 10 in their decision-making, tools to guide authors through the journal selection process have started to emerge, such as ThinkCheckSubmit (http://thinkchecksubmit.org/). Recently, COPE, OASPA, DOAJ, and WAME produced principles of transparency against which, among other measures, DOAJ assesses journals in part, before they can be listed in the database (https://doaj.org/bestpractice). We also encourage researchers to examine all journals for quality and legitimacy using the characteristics in Table 10 when making a decision on where to submit their research. As the journal landscape changes, it is no longer sufficient for authors to make assumptions about the quality of journals based on arbitrary measures, such as perceived reputation, impact factor, or other metrics, particularly in an era where bogus metrics abound or legitimate ones are being imitated.

This study examined most of Beall's criteria for identification of predatory publishers and journals together with items from the COPE and OASPA. While many of the characteristics we examined were useful to distinguish predatory journals from presumed legitimate journals, there were many that do not apply or that are not unique to predatory journals. For instance, defining criteria of predatory journals [4] suggest that no single individual is named as an editor and that such journals do not list an editorial board. We found that this was not the case in over two thirds of predatory journals and, in fact, a named EIC could not be identified for 26 (13.07%) of the presumed legitimate journals in our sample. Such non evidence-based criteria for defining journals may introduce confusion rather than clarity and distinction.

The existing designation of journals and publishers as predatory may be confusing for other reasons. For instance, more than one presumed-legitimate publisher has appeared on Beall's list [19]. In October 2015, Frontiers Media, a well-known Lausanne-based open access publisher, appeared on Beall's List [20]. Small, new, or under-resourced journals may appear to have the look and feel of a potential predatory journal because they do not have affiliations with large publishers or technologies (e.g., manuscript submission systems) or mature systems

and the features of a legitimate journal. This is in line with our findings that journals from low-resourced (LMIC) countries were more often in the potentially predatory group of journals than either of the presumed-legitimate journal arms. However, this does not imply that they are necessarily predatory journals.

Another limitation is that the majority of the open access biomedical journals in our sample (95%) charged an APC, while generally many open access journals do not. May 2015 was the last time that the DOAJ provided complete information regarding APCs of journals that it indexes (fully open access, excluding delayed or partial open access). At that time, approximately 32% of journals charged an APC. At the time of writing this article, approximately 40% of medical journals in DOAJ appear to charge an APC. However, these figures do not account for the hybrid-subscription journals that have made accommodations in response to open access, many of which are included in our sample of subscription-based journals. For such journals, our data and that of others [21] show that their fees appear to be substantially higher than either potential predatory or fully open access journals.

In context of other research

To the best of our knowledge this is the first comparative study of predatory journal publishing and legitimate publishing models aimed at determining how they are different and similar. Previously, Shen and Björk [22] examined a sample of about 5% of journals listed on Beall's List for a number of characteristics, including three that overlap with items for which we collected data: APC, country of publisher, and rapidity of (submission to) publishing [22]. In a large part, for the characteristics examined, our findings within the predatory journal group are very similar. For example, Shen and Björk [22] found the average APC for single publisher journals to be $98 USD, which is very similar to our results ($100 USD). They also found that 42% of single predatory journal publishers were located in India, whereas our estimates were closer to 62%. Differences between their study and ours may exist because we focused on biomedical journals while they included all subject areas.

Limitations

It was not possible to fully blind assessors to study groups since, given the expertise of team members, a minimum knowledge of non-predatory publishers was expected. In addition, we could only include items that could be assessed superficially rather than those requiring in-depth investigations for each journal. Many items can and should be investigated further.

Since some characteristics are likely purposely similar between journals (e.g., journals from all groups claim to be open access and indicate carrying out peer review) [14], and it was difficult to anticipate which, we did not carry out a logistic regression to determine whether characteristics were likely to be associated with predatory or presumed legitimate journals.

Conclusions

This research initiates the evidence-base illuminating the difference between major publishing models and, moreover, unique characteristics of potential predatory (or illegitimate) journals (Table 10).

The possibility that some journals are predatory is problematic for many stakeholders involved in research publication. Most researchers are not formally trained on publication skills and ethics, and as such may not be able to discern whether a journal is running legitimate operations or not. For early career researchers or for those who are unaware of the existence or characteristics of predatory journals, they can be difficult to distinguish from legitimate journals. However, this study indicates that predatory journals are offering at least 18-fold lower APCs than non-predatory journals, which may be attractive to uninformed authors and those with limited fiscal resources. Assuming that each journal publishes 100 articles annually, the revenues across all predatory journals would amount to at least a $USD 100 million dollar enterprise. This is a substantial amount of money being forfeited by authors, and potentially by funders and institutions, for publications that have not received legitimate professional editorial and publishing services, including indexing in databases.

Established researchers should beware of predatory journals as well. There are numerous anecdotes about researchers (even deceased researchers [23]) who have been put on a journal's editorial board or named as an editor, who did not wish to be and who were unable to get their names delisted [24]. Aside from this potentially compromising the reputation of an individual that finds him or herself on the board, their affiliation with a potential predatory journal may confer legitimacy to the journal that is not deserved and that has the potential to confuse a naïve reader or author. As our findings indicate, this phenomenon appears to be a clear feature of predatory journals.

In addition to the costs and potential fiscal waste on publication in predatory journals, these journals do not appear to be indexed in appropriate databases to enable future researchers and other readers to consistently identify and access the research published within them. The majority of predatory journals indicated being 'indexed' in Google Scholar, which is not an indexing database. Google does not search pre-selected journals (as is the case with databases such as Medline, Web of Science, and Scopus), rather it searches the Internet for

scholarly content. Some potentially predatory journals indicate being indexed in well-known biomedical databases; however, we have not verified the truthfulness of these claims by checking the databases. Nonetheless, if legitimate clinical research is being published in predatory journals and cannot be discovered, this is wasteful [25], in particular when it may impact systematic reviews. Equally, if non-peer reviewed, low quality research in predatory journals is discovered and included in a systematic review, it may pollute the scientific record. In biomedicine, this may have detrimental outcomes on patient care.

Future research

What is contained (i.e., 'published') within potential predatory journals is still unclear. To date, there has not been a large-scale evaluation of the content of predatory journals to determine whether research is being published, what types of studies predominate, and whether or not data (if any) are legitimate. In addition, we have little understanding of who is publishing in predatory journals (i.e., experience of author, geographic location, etc.) and why. Presumably, the low APC is an attractive feature; however, whether or not authors are intentionally or unintentionally publishing within these journals is critical to understanding the publishing landscape and anticipate future potential directions and considerations.

The findings presented here can facilitate education on how to differentiate between presumed legitimate journals and potential predatory journals.

Abbreviations

AIM: Abridged Index Medicus; APC: article processing charge; CONSORT: CONsolidated Standards Of Reporting Trials; COPE: Committee On Publication Ethics; DOAJ: Directory Of Open Access Journals; EIC: editor-in-chief; EQUATOR: Enhancing the QUAlity and Transparency of health Research; ISSN: international standard serial number; JIF: journal impact factor; LMIC: low- or middle-income country; OASPA: Open Access Scholarly Publishers Association; PLOS: Public Library Of Science; PRISMA: Preferred Reporting Items for Systematic reviews and Meta-Analyses; STARD: STAndards for Reporting Diagnostic accuracy; STROBE: STrengthening the Reporting of OBservational studies in Epidemiology; USD: United States Dollar

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Availability of data and materials

The screening and data extraction forms used, and the data generated, in this study are available from the authors on request.

Authors' contributions

DM and LS conceived of this project and drafted the protocol, with revisions by VB. RB, JC, JG, OM, DM, JR, LS, BJS, and LT were involved in the conduct of this project. LS and LT performed analysis of data. LS drafted the manuscript. All authors provided feedback on this manuscript and approved the final version for publication.

Competing interests

VB is the Chair of COPE and the Executive Director of the Australasian Open Access Strategy Group.

Consent for publication

Not applicable.

Ethics approval and consent to participate

Not applicable.

Transparency declaration

David Moher affirms that this manuscript is an honest, accurate, and transparent account of the study being reported, that no important aspects of the study have been omitted, and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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References

1. Bethesda Statement on Open Access Publishing. http://legacy.earlham.edu/~peters/fos/bethesda.htm. Accessed 31 Mar 2016.
2. Morrison H, Salhab J, Calve-Genest A, Horava T. Open access article processing charges: DOAJ survey May 2014. Publications. 2015;3:1–16.
3. Crotty D. Is it True that Most Open Access Journals Do Not Charge an APC? Sort of. It Depends. The Scholarly Kitchen on WordPress.com. The Scholarly Kitchen. 2015. http://scholarlykitchen.sspnet.org/2015/08/26/do-most-oa-journals-not-charge-an-apc-sort-of-it-depends/. 4 Apr 2016.
4. Beall J. Beall's List: Potential, Possible, or Probable Predatory Scholarly Open-Access Publishers. 2015. http://scholarlyoa.com/publishers/. Accessed 7 Jan 2016.
5. Beall J. Criteria for Determining Predatory Open-Access Publishers. 1st ed. 2012. http://wp.me/p280Ch-g5. Accessed 1 Apr 2014.
6. Beall J. Criteria for Determining Predatory Open-Access Publishers. 2nd ed. 2012. http://scholarlyoa.com/2012/11/30/criteria-for-determining-predatory-open-access-publishers-2nd-edition/. Accessed 5 July 2016.
7. Beall J. Criteria for Determining Predatory Open-Access Publishers. 3rd ed. 2015. https://scholarlyoa.files.wordpress.com/2015/01/criteria-2015.pdf. Accessed 1 July 2016.
8. Dadkhah M, Bianciardi G. Ranking predatory journals: solve the problem instead of removing it! Adv Pharm Bull. 2016;6(1):1–4.
9. Glick M, Springer MD, Bohannon J, Bohannon J, Shen C, Björk B-C. Publish and perish. J Am Dent Assoc Elsevier. 2016;147(6):385–7.
10. Clark J, Smith R. Firm action needed on predatory journals. BMJ. 2015; 350(jan16_1):h210.
11. Caplan AL, Bohannon J, Beall J, Sarwar U, Nicolaou M, Balon R, et al. The problem of publication-pollution denialism. Mayo Clin Proc. 2015;90(5):565–6.
12. Eisen M. Door-to-Door Subscription Scams: The Dark Side of The New York Times. It is NOT Junk. 2013. http://www.michaeleisen.org/blog/?p=1354. Accessed 22 Jun 2016
13. Moher D, Srivastava A. You are invited to submit…. BMC Med. 2015;13:180.
14. Bohannon J. Who's afraid of peer review. Science. 2013;342:60–5.
15. Fact SheetMEDLINE® Journal Selection. U.S. National Library of Medicine. https://www.nlm.nih.gov/pubs/factsheets/jsel.html. Accessed Apr 2014.
16. Selection C. Abridged Index Medicus. N Engl J Med. 1970;282(4):220–1.
17. U.S. National Library of Medicine. MEDLINE Policy on Indexing Electronic Journals. https://www.nlm.nih.gov/bsd/policy/ejournals.html. Accessed 26 Jul 2016.
18. Van Noorden R. Open access: the true cost of science publishing. Nature. 2013;495(7442):426–9.
19. Butler D. Investigating journals: the dark side of publishing. Nature. 2013; 495(7442):433–5.
20. Bloudoff-Indelicato M. Backlash after Frontiers journals added to list of questionable publishers. Nature. 2015;526(7575):613.

21. Wellcome Trust. Wellcome Trust and COAF Open Access Spend, 2014-15. Wellcome Trust blog. 2015. https://blog.wellcome.ac.uk/2016/03/23/wellcome-trust-and-coaf-open-access-spend-2014-15/. Accessed 21 Jun 2016
22. Shen C, Bjork B-C. 'Predatory' open access: a longitudinal study of article volumes and market characteristics. BMC Med. 2015;13:230.
23. Spears T. The Editor is Deceased: Fake Science Journals Hit New Low. Ottawa: Ottawa Citizen; 2016.
24. Kolata G. For Scientists, an Exploding World of Pseudo-Academia. NYTimes.com. 2016. http://www.nytimes.com/2013/04/08/health/for-scientists-an-exploding-world-of-pseudo-academia.html?pagewanted=all. Accessed July 2016.
25. Chan AW, Song F, Vickers A, Jefferson T, Dickersin K, Gøtzsche PC, et al. Increasing value and reducing waste: addressing inaccessible research. Lancet. 2014;383(9913):257–66.

Appendix 5: Copyright permission

Potential predatory and legitimate biomedical journals: can you tell the difference? A cross-sectional comparison

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Publication: BMC Medicine

Publisher: Springer Nature

Date: Mar 16, 2017

Chapter 3: Do predatory journals publish biomedical research?

Chapter 2 revealed many ways in predatory journals appeared to be different from legitimate journals. Yet, they were also observed to be similar in some ways. For example, most predatory journals (89%) described themselves as "open access" as did 94% of legitimate open access journals. However, most predatory journals did not appear to offer the copyright (10%) and licensing options (24%) typically accompanying open access publishing that permits broad re-use and distribution (i.e., creative commons licenses). At least 90% of legitimate open access journals did. Ninety-five percent of predatory journals, 100% of legitimate open access journals, and 92% of legitimate hybrid-subscription journals indicated being peer reviewed. However, investigations repeatedly suggest that predatory journals do not peer review submissions, or at least not in any meaningful way (1–3), thus supporting claims that predatory journals may be deceptive about their practices (4,5). Deception and the concealment of information (such as author publishing fees), were stated as the primary reasoning in the US Federal Trade Commission imposing a $50 million fine against one the largest know predatory publishers, *OMICS Publishing Group* (6). This is important since researchers indicate encountering predatory journals primarily through email solicitations directing them to the journal's website or via an internet search, and assume them to be legitimate when submitting to them (7).

Predatory journals are criticized for their deceptive and non-transparent practices, particularly false claims around their peer review (8). In June 2017, WAME released a statement recommending that journals publishing scientific work that "is not properly vetted[…]should not contribute to the scientific record" (9). This assumes that research that is not peer reviewed has no scientific value (10–12). Predatory journals are known to publish fabricated and falsified research (1,13) as well as papers containing academic exercises in silliness (2,14), all without peer review. While such 'sting' operations demonstrate the complete lack of or, at best, light peer review at predatory journals, they tell us little about the remaining content of predatory journals – that submitted under the assumption that the such journals are legitimate.

Predatory journals and the content they publish appears to be increasing year over year. What was documented as 126 journals and 225 publishers (with an unquantified number of journals) by Jeffrey Beall in 2013 (15) was at least 13,000 journals (Cabell's International) at the time of writing (early 2020) (16). 53,000 articles were estimated to be published in journals on Beall's List in 2010, with a projection of 420,000 in 2014 (17). This number may be overexaggerated, however, since 25% of predatory journals on Beall's list appear to be inactive (i.e. do not publish articles) beyond their initial 2 years and 40% appear to be inactive after 4 years (18). *The Guardian* estimated that the largest five predatory publishers (by number of journals) had cumulatively published at least 175,000 articles as of 2018 (11). Nonetheless, based on the large volume of articles estimated to be contained in predatory journals, concluding that their content unanimously represents fraud, frivolous activities, or otherwise untrustworthy research that ought to be disregarded from scientific consideration (9,19) may be premature. Broad investigation into their contents is thus warranted.

What is published in predatory journals?

For researchers to continue to submit to predatory journals in such numbers that their presence is sustained, suggests that they are providing a valuable service for some researchers. Understanding the scientific content being sent to predatory journals and how well it is reported, may provide some indication of whether they publish anything of scientific value and ultimately worth considering in the scholarly record. To this end, Chapter 4 aims to characterise the epidemiology and reporting of biomedical research published in predatory journals.

References

1. Bohannon J. Who's afraid of peer review. Science. 2013;342:60–5.

2. Neuroskeptic. Predatory Journals Hit By 'Star Wars' Sting [Internet]. Discover Magazine. 2017 [cited 2017 Aug 5]. Available from: http://blogs.discovermagazine.com/neuroskeptic/2017/07/22/predatory-journals-star-wars-sting/#.WlAZN1Q-fOR

3. Spears T. This 'predatory' science journal published our ludicrous editorial mocking its practices. Ottawa Citizen. 2017 Jan;

4. Butler D. Investigating journals: The dark side of publishing. Nature. 2013 Mar 27;495(7442):433–5.

5. Ferris LE, Winker MA. Ethical issues in publishing in predatory journals. Biochem Medica. 2017 Jun 15;27(2):279–84.

6. Court Rules in FTC's Favor Against Predatory Academic Publisher OMICS Group; Imposes $50.1 Million Judgment against Defendants That Made False Claims and Hid Publishing Fees [Internet]. Federal Trade Commission Press Releases. 2019 [cited 2019 Jun 10]. Available from: https://www.ftc.gov/news-events/press-releases/2019/04/court-rules-ftcs-favor-against-predatory-academic-publisher-omics

7. Cobey KD, Grudniewicz A, Lalu MM, Rice DB, Raffoul H, Moher D. Knowledge and motivations of researchers publishing in presumed predatory journals: a survey. BMJ Open. 2019 Mar 23;9(3):e026516.

8. Lukic T, Blesic I, Basarin B, Ivanovic B, Milosevic D, Sakulski D. Predatory and fake scientific journals/publishers - a global outbreak with rising trend: a review. Geogr Pannonica. 2014;18:69–81.

9. Laine C, Winker MA. Identifying Predatory or Pseudo-Journals [Internet]. Vol. 27, Biochemia Medica. 2017 [cited 2017 Feb 27]. p. 285–91. Available from: http://www.biochemia-medica.com/system/files/27_2_C.Laine et al._Identifying predatory or pseudo-journals.pdf

10. Science's fake journal epidemic : Naturejobs Blog [Internet]. [cited 2020 Feb 20]. Available from: http://blogs.nature.com/naturejobs/2017/06/26/sciences-fake-journal-epidemic/

11. Hern A, Duncan P. Predatory publishers: the journals that churn out fake science. The Guardian. 2018;

12. Gillis A. The Rise of Junk Science. The Walrus. 2019;

13. Spears T. Blinded by scientific gobbledygook [Internet]. Ottawa Citizen. 2014 [cited 2019 Nov 7]. Available from: https://ottawacitizen.com/news/local-news/blinded-by-scientific-gobbledygook

14. Stromberg J. 'Get Me Off Your Fucking Mailing List' is an actual science paper accepted by a journal [Internet]. Vox. 2014. Available from: www.vox.com/2014/11/21/7259207/scientific-paper-scam

15. Carey K. A Peek Inside the Strange World of Fake Academia. The New York Times. 2016 Dec 29;

16. Cabells Journal Blacklist hits 12,000 Mark | STM Publishing News [Internet]. [cited 2019 Dec 18]. Available from: http://www.stm-publishing.com/cabells-journal-blacklist-hits-12000-mark/

17. Shen C, Bjork B-C, Björk B. 'Predatory' open access: a longitudinal study of article volumes and market characteristics. BMC Med. 2015 Dec 1;13(1):230.

18. Crawford W. Gray OA 2012-2016: Open access journals beyond DOAJ. Cites & Insights. 2017;17(1).

19. Beall J. Ban predators from the scientific record. Nature. 2016 Jun 15;534(7607):326–326.

Chapter 4: Assessing the scientific content of predatory journals

Note: The main text of this chapter appeared as a supplement to the published article as a detailed account of the methods and results of the study. The published article representing this chapter is a "news" style summary of the work, found in Appendix 3.

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Link to published article	https://www.nature.com/news/stop-this-waste-of-people-animals-and-money-1.22554
Supplementary materials	Study Protocol: https://osf.io/6tr54/ Study Forms & Data: https://osf.io/uydvr/ Original research article: https://www.nature.com/news/polopoly_fs/7.46207.1504703578!/suppinfoFile/549023a_S1.pdf and https://osf.io/s7b3k/
Abbreviations	AHRQ-EPC: Agency for Healthcare Research and Quality's Evidence-based Practice Centre program APC: Article process charge ARRIVE: Animal Research: Reporting of In Vivo Experiments CONSORT: CONsolidated Standards Of Reporting Trials PRISMA: Preferred Reporting Items for Systematic reviews and Meta-Analyses STARD: STAndards for Reporting Diagnostic accuracy STROBE: STrengthening the Reporting of OBservational studies in Epidemiology CV: Curriculum Vitae NIH: National Institutes of Health USD: United States Dollar
Appendices	Appendix 1: Author Contributions Appendix 2: Supplementary Tables and Calculations Appendix 3: Published article Appendix 4: Copyright permission

Assessing the scientific content of predatory journals

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Abstract

Entities that have become known as 'predatory' journals and publishers are permeating the world of scholarly publishing, yet little is known about the papers they publish. We examined a cross-section of 1907 human and animal biomedical studies, recording their study designs, epidemiological and reporting characteristics. In our sample more than two million humans and over eight thousand animals were included in predatory publications. Only 40% of studies report having ethics approval. Of the 17% of articles reporting their funding source, the US National Institutes of Health was most frequently named. Corresponding authors were most often from India (511/1907, 26.8%) and the US (288/1907, 15.1%). The reporting quality of work reported in our sample was poor and worse than contemporaneous samples from the legitimate literature. Many studies were missing key methodological details and findings. Our results raise important ethical concerns since research in predatory journals is difficult to identify and not indexed in scientifically curated biomedical databases. Funders and academic institutions need to develop explicit policies to drive grantees and prospective authors away from these entities.

Background

Entities that have become known as 'predatory' publishers and journals (Box 1) have ensconced themselves as part of the fabric of academic publishing (1). These entities are becoming increasingly common and are now publishing articles at an alarming rate (2). They are thought to be exploiting the open-access publishing model and the 'publish or perish' mantra in academia. They promote themselves as 'open-access', providing peer review, and having an impact factor, while boasting article processing charges (APCs) that are a fraction of the cost of legitimate open-access journals (<$150 USD (3)). Their listed editors and staff often do not have a legitimate association with the journal or seem to be contrived[3]. In addition, these outlets fail to use copyright typical of open access or to provide critical information about journals' ethics policies (3).

Box 1 Defining 'Predatory' Journals

The term 'predatory' journal was coined and popularized by librarian Jeffrey Beall[1] to describe publishers and journals lacking the ethics, integrity, and operating standards of their recognized, legitimate counterparts

- Until 15 January 2017, Jeffrey Beall maintained the website *Scholarly Open Access*, listing "potential, possible, or probable predatory" publishers and journals here: www.scholarlyoa.com
- These lists collectively became known as "Beall's List"
- The process Beall used to designate journals and publishers as 'predatory' was not evidence based or clear
- Our understanding is that:
    1. Predatory journals were identified as Beall encountered them
    2. Journals had to meet *some* of the >50 criteria pre-specified by Beall.
    3. Judgment as 'predatory' unilaterally by Beall

While much has been written about the questionable scientific and business practices of predatory journals (4,5), we know little about their content. For example, do they publish clinical research, such as randomized trials and/or preclinical research, such as in vivo studies? For the research that is published what is the impact of apparent non-existent peer review and editorial oversight (6)? These questions and others are important because the content from these entities is permeating the scholarly record. Some publications from these journals, while not typically indexed in scientifically curated bibliographic databases (e.g., Medline), are being picked up by non-discriminating sources such as Google Scholar or PubMed Central [i.e., repository for National Institutes of Health (NIH)-funded research and other publicly accessible full-text research].

The ethical issues of predatory publishing entities are twofold. If research is being published in predatory journals, it is unlikely be effectively scrutinized by peer review (6), and, perhaps more significant, important research may never reach end users including patients, clinicians, or policymakers, and may never be included in future research (e.g. in systematic reviews) because it cannot be easily identified. In this research, we set out to: 1) Characterize what biomedical research is being published in predatory journals, and 2) Determine the completeness of reporting of the most common clinical study designs.

Methods

We evaluated a cross section of biomedical research published in predatory journals using the following methods.

Research Team

Thirty-two people were involved in the project, led by a core group (DM, LS, KDC, JG, ML, MTA). The team was experienced in extracting information from a broad spectrum of primary clinical and preclinical studies and assessing the quality of such research. Several members of the team also had specific expertise examining predatory journals and publishers. The protocol was deposited in the Open Science Framework (OSF) (https://osf.io/r2gj6/) as well as the University of Ottawa Open Access repository (http://www.ruor.uottawa.ca/handle/10393/34253) prior to data extraction.

Team Training

Prior to conducting the study, all team members involved in the extraction process were required to participate in a minimum two-hour training session, given by three members of the core group (DM, LS, KDC). The training included a brief overview of predatory journals and the project, a detailed discussion and review of the designs of clinical and preclinical studies, and an exercise in categorizing five different types of clinical and preclinical study designs identified by the core team. The training ended with an overview of the project management online software program used to perform the work, DistillerSR (Evidence Partners, Ottawa, Canada). The research team subsequently met for information sessions throughout the duration of the project and the core group was available for any additional questions, in person or via e-mail. Here we describe the methods used, including some minor amendments from those described in our protocol.

Journal Sampling Strategy

We used the Scholarly Open Access website (http://scholarlyoa.com) as the source of journals from which to obtain articles to include in this study. Content of this website was removed on 15 January 2017 (reason unknown) (7), however, archived versions of the website and lists are available through https://archive.org/. Within the website, two lists of 'potential, possible, or probable predatory scholarly open-access' publishers had been maintained: 1) single journal publishers (e.g. 'standalone' journals) and 2) multiple journal publishers (e.g. publishers publishing more than one journal). For the list of single journal publishers, we based our selection of journals on a previous study, with modifications as described below; the process of journal selection is described elsewhere[3]. For the list of multiple journal publishers, the process and methods of journal selection is fully described below.

Single publisher journals

In a previous study (3), of 397 single journal publishers listed on the Scholarly Open Access website in July 2014 (http://web.archive.org/web/20140706180853/http://scholarlyoa.com/individual-

journals/), 81 were deemed as having a fully biomedical scope, according to Medline's journal selection criteria https://www.nlm.nih.gov/pubs/factsheets/jsel.html. For the current study, from the 81 journals, we selected only those evaluated as part of the previous study, leaving us with 45 biomedical journals. If, at the time of article retrieval, any of these journals contained no content or listed articles of which none could be retrieved, we replaced them with another journal (from the pool of 36 remaining biomedical journals).

Multiple Journal Publishers

As of 17 December 2015, 923 publishers were listed on the Scholarly Open Access website list of multiple journal publishers (http://web.archive.org/web/20141129175402/http://scholarlyoa.com/publishers/?). We recorded this list of publisher names and URLs in Microsoft Excel (version 14.7.1, Microsoft Corporation, Seattle, Washington, USA) and selected a 20% sample of publishers (n = 185) using a random number generator. One team member (A. Srivastava) visited each publisher's website and obtained the name and URL for all listed journals. Five team members (DM, LS, KDC, JG, MTA) screened the resulting list of journals to determine which were biomedical. To do this, two assessors independently scrutinized each journal's website to find the listed scope of each journal, and applied the Medline journal selection criteria (as above) to determine which were biomedical journals. Assessors noted whether each journal's scope was fully or partially biomedical. Disagreements in screening were resolved by third party arbitration. Of journals identified as fully biomedical, we randomly selected 200 (using a random number generator) for inclusion in our sample. Journals in this sample that did not list any articles, or listed articles of which none could be retrieved, were replaced with another randomly selected fully biomedical journal to maintain the sample of 200 journals.

Identifying Articles for Inclusion

For the 245 journals we identified (see Fig.1A), one of four team members (PB, MG, LS, II) visited each journal's website and sought PDFs of the published articles. Up to 25 of the most recently published articles were downloaded. Based on previous experience examining presumed predatory journals, we anticipated that some of the journals would not list their content chronologically. For such journals, we identified articles using the following approach:

1. Where articles were organized according to study design, they were obtained in the following preferential order: clinical trials, systematic reviews, observational studies, preclinical studies, diagnostic accuracy studies, case reports, non-systematic reviews, and opinions/commentaries/editorials. As such, if there were ≥25 clinical trials, in addition to other study types, we obtained only 25 clinical trials, starting with the most recently published if a chronology was apparent within the study design grouping;
2. If studies were ordered by topic area, we selected up to 25 articles from what we believed to be biomedical topics. For example, if the journal published on biology and pharmacy, and articles were sectioned under these two headings, we first retrieved up to 25 articles from the section containing pharmacy articles (i.e., direct biomedical topic) prior to retrieving any remaining articles from the biology section. If studies were listed by topic

area, but multiple biomedical topics were apparent (e.g., psychiatry and neurology), we retrieved articles from the first relevant category, moving to the next only if the first category contained fewer than 25 articles; and

3. Where articles were not ordered by date of publication, study design, or topic area, we obtained up to 25 articles in the order they appeared on the journal website. When a journal was encountered that published no articles, we excluded the journal from our sample and replaced it with another, as described above.

The process of identifying articles for extraction of characteristics is depicted in Fig.1B. We aimed to obtain a sample of articles describing clinical or preclinical (*in-vivo*) research. Two assessors independently screened each article to identify those describing research in humans or whole animals (i.e., *in-vivo*). Methods research and non-research articles such as protocols, editorials, commentaries, opinion pieces, and letters to the editor were excluded. Non-biomedical research, such as social science research, and research on agriculture, livestock, and wildlife were also excluded.

Extraction of Epidemiological Characteristics

The following information was extracted from each included article, where available: the corresponding author's name (or last author if no corresponding author was indicated), email address, academic affiliation, and affiliated country; journal and publisher location (country); month and year of publication; number of authors; whether ethics approval was obtained; funder name; study design (as stated by authors); sample size or number of included participants. We also made an assessment of the broad ICD-10 classification of disease being reported (http://apps.who.int/classifications/icd10/browse/2016/en), the type of funders (government, industry for profit, non-profit organization, academic), study design of each included article (author-stated design; and reviewer-assessed design determined using a combination of approaches from the following tools: Penelope (http://www.peneloperesearch.com/equatorwizard/) and a study classification algorithm developed by the Agency for Healthcare Research and Quality's Evidence-based Practice Centre program (AHRQ-EPC).

Five members of the core group (LS, KDC, JG, ML, MTA) piloted the data extraction form on multiple articles and refined it until there was agreement on at least 80% of items across assessors. Following this pilot exercise, members of the larger team received specific training on the form, and two team members independently completed data extraction for each article. Disagreements were resolved by third party arbitration.

Completeness of Reporting Assessment

For feasibility, we assessed a purposeful selection of our sample for reporting completeness. For articles reporting multiple preclinical studies, we assessed the first *in-vivo* study reported in the article. In addition, due to their more direct impact on health care, we also assessed the completeness of reporting for the following seven clinical research designs: systematic reviews or

meta-analyses of clinical trials; randomized controlled trials; non-randomized clinical trials; case-control studies; observational cohort studies; cross sectional studies; and diagnostic test accuracy studies. For primary clinical research studies, we excluded those reporting on multiple studies (e.g. two different cohort studies) or multiple designs (e.g. case report and cohort study in a single article or nested studies).

When available, the author-stated study design was used as the default for study design categorization. When authors did not state a study design, two independent reviewers assessed the design for categorization. For these studies, prior to evaluating reporting, assessors were asked to confirm whether they agreed with the designated study design. If not, a third verification of study design was undertaken by one of 3 assessors (DM, LS, or KT).

We used modified reporting guideline checklists to guide the assessment of completeness of reporting (Appendix 2). The final version of each checklist used in this project is provided in S2 to S9. For each study, checklist items were assessed as 'not reported' (no information was present about the particular item), 'completely reported' (all components of the item were addressed somewhere in the article text), or 'partially reported' (some but not all details of an item was provided somewhere in the text).

Five members of the core team piloted the reporting assessment forms using multiple articles for each study type form and refined the forms until there was agreement on at least 80% of items across assessors. Following this pilot exercise, members of the larger team were given a 1.5-hour training session on how to assess reporting using the forms. Team members were also provided with examples of good reporting taken from the relevant reporting guidelines documents. Two team members independently assessed the completeness of reporting for each study. Disagreements were resolved by third party arbitration.

Data Management

Data were managed using a combination of tools. The list of journals and publishers obtained from the *Scholarly Open Access* website were recorded in Microsoft Excel, which was also used to track and extract journal names and URLs from publishers. The PDFs of journal articles were manually retrieved from journal websites (at the time of writing, we are unaware of any scientifically curated bibliographic database indexing content from these journals) and uploaded to DistillerSR. We used DistillerSR to facilitate screening of biomedical journals and articles for inclusion, for extraction of epidemiological characteristics for each article, and for assessing the completeness of reporting of included studies.

De-duplication

We began this study under the assumption that the publishers and journals (and articles within them) from the two lists we obtained from the *Scholarly Open Access* website were unique. Since we are unaware of any database that indexes these journals and the articles they publish, bibliographic citations for articles were unavailable to us, preventing the use of traditional de-duplication methods (e.g., using reference management software). During data extraction,

cleaning, and analysis, we encountered several instances of duplicate publications. As such, we carried out a post-hoc investigation into duplicates at both the journal and article level.

For all 245 included journals, we used Microsoft Excel's duplicate detection function to identify whether any journal names were duplicated. For each duplicated name, we checked whether the URL was also duplicated. If it was, the journal was deemed a duplicate and the latter instance (higher reference number in our sample) was removed. For journals with the same name but different URLs, we visited each URL and compared the websites. By this process, we found 11 pairs of journals with the same name and identical looking websites but with unique URLs from two different publishers (e.g., Advance Journals and BioMed Research). The latter instance (i.e. higher reference number in our sample) of each duplicate journal was removed. Associated articles from duplicate journals were also identified and removed. At the article level, we used extracted data to facilitate duplicate detection. In Excel, we used the duplicate detection function to identify duplicate corresponding (or last) author names. For each set of duplicates, we assessed whether the extracted email address and the extracted number of authors were the same. If both of these conditions were true, we visited the article PDFs and visually inspected them to determine whether they were reporting on the same study. For each duplicate detected we excluded the instance with the assigned higher reference number in our sample. We identified one journal (Reviews of Progress) listed in both the single and multiple journal publisher lists. Results of these duplicate detection processes are incorporated into Fig.1A and Fig.1B.

Data Analysis

Data were exported from DistillerSR into Microsoft Excel, where they were cleaned. One of five assessors (LS, KDC, JG, ML, MTA) resolved discrepancies in the data entered into open text boxes. Two people (JG and ML) independently categorized data collected on funding sources into five categories (government, academic, industry, unfunded explicitly stated, funding source not stated; discrepancies resolved by consensus) by running a Google search of each named funder and making a judgment about category assignment. The analysis was carried out using Stata/IC (version 13.1, StataCorp, College Station, Texas, USA). Fig. 3 was created using QGIS (version 2.18, QGIS Development Team).

Descriptive summary statistics were used to analyze the epidemiological characteristics. Specifically, we calculated the median and interquartile range for continuous data items and proportions for dichotomous items. Categorical items were reported as counts within each category. Completeness of reporting was summarized as the proportion of articles (within a given study design) reporting within each response category (yes, no, partial) for each checklist item. These findings were depicted via radar diagrams, which present the proportion of articles completely reporting, and both completely and partially reporting, each checklist item for a given study design.

Differences Between Protocol and Study

The methods above describe the steps that were followed to complete this study. Below is a listing of departures from the planned methods and analyses described in our protocol: https://osf.io/6tr54/

1. We de-duplicated articles manually using the method described above (De-duplication)
2. For feasibility, we included only full-text articles; abstracts and conference proceedings were excluded.
3. Due to the large number of case reports and case series we encountered, we categorized their study design as such (rather than labeling them 'other').
4. We collected the number of included participants for all research studies, rather than just those included in the reporting assessment.
5. We collected the funder name for any affiliated funding including investigator funding, research chairs, etc. (i.e., not just for project-related funding), as it was not always possible to distinguish between types of funding.
6. We (LS, DM, or KT) made a systematic verification/determination of study designs if not reported by study authors and if there were discrepancies between assessors in the categorization of study design; all assessors performed an additional verification of the designated study design as encountered during the reporting assessment.
7. Since the majority of reporting items were judged as "Partially Reported" across study designs, we added a layer representing "Yes" + "Partial" in addition to "Yes" (originally planned) to the radar diagrams depicting reporting assessments.
8. We categorized author location by 2014 World Bank (Organization for Economic Co-operation and Development) income level.
9. We did not explore differences between single-publisher journals and multiple-publisher journals as planned; we did not feel there was a sufficient basis for doing so.
10. We did not examine differences in epidemiological characteristics between level of reported funding (yes/no) and reports of research approved by ethics committees (yes/no) as planned as there were too few articles reporting this information for comparisons to be meaningful.
11. At the request of the publishing journal (*Nature*) we carried out the following:
    a. We confirmed that studies naming NIH as a funder of the research were likely to have true affiliations with NIH. We did this by searching for the study key words, authors, or grant numbers in the NIH funding database, NIH RePORTER.
    b. We checked whether NIH-funded studies and US authors were concentrated in particular journals. To do this, we performed a cross tabulation of articles with authors from the US (Table S11) or with NIH-funding (Table S12) against the publishing journal.
    c. We counted the number of distinct corresponding authors at D.Y. Patil University, University of Tehran, University of Texas, and Harvard University. (Table S13)
    d. We summarized the number of articles with the same corresponding (or last) author. (Table S14)

Results

Of 397 single-journal predatory publishers and 923 multiple-journal predatory publishers we initially identified, after exclusions of duplicates, we included 236 biomedical journals and 3702 articles (Fig.1A; Fig.1B). Very few journals (59/236; 25.0%) reported their location (Table 1). Of those that did, the primary location was India (19/59, 32.2%), followed by the US (17/59; 28.8%). Nearly 30% of the total journals we sought articles from had no published articles listed (99/343) and were replaced by another journal. Journals contained a median of 19 articles (of a maximum of 25 we sought), we were only able to obtain our pre-set maximum of 25 articles for 42% (100/236) of our sample. We determined that 1907/3702 (51.5%) of the identified articles reported on primary biomedical research, or were systematic reviews of humans or animals. We evaluated the epidemiological characteristics of these articles (Fig.1B). We found that 1499 (1499/1907; 78.6%) reported on a single clinical study using a single design; 201 (201/1907; 10.5%) reported preclinical *in vivo* studies. Articles in our sample were published between 2009 and 2016; the median year of publication was 2015 (Table 2). There was a median of four authors per article.

Publishing in predatory journals is a global phenomenon. Approximately one-sixth of the corresponding authors were from the US (288/1907; 15.1%) and just over a quarter were from India (511/1907, 26.8%) (Fig.2). More than half of the authors were from high or upper middle-income countries (57%). Authors were from a variety of institutions. The most frequently named author-affiliated institutions were from India (3 institutions), USA (2 institutions), Nigeria (1 institution), and Iran (1 institution) (Table 2).

Across biomedical human and animal studies, approximately a third reported obtaining ethics approval (724/1817; 39.8%; Table 3). More than half of these studies did not contain any information about whether they obtained ethics approval (1076/1817; 59.2%), while a few explicitly noted they did not have ethical approval (17/1817; 0.9%). There were 345 different funders reported in 323 publications; 1397 out of the 1907 (73.3%) publications did not report any information about funding, while just 187 out of 1907 (9.8%) noted they were not funded. The US NIH was the most prevalent funder in our sample (41/323; 12.7%). Two of the other largest funders were based in India (University Grants Commission: 15/323, 4.6%; Indian Council of Medical Research: 8/323, 2.5%). Funders were primarily academic (e.g., academic: 124/345, 35.9%) or government agencies (122/345, 35.4%).

1556 (81.6%) of studies we examined reported on clinical research, the remainder were preclinical (Table 4). The majority of primary clinical studies did not include a sample size calculation. Data collected from more than 2 million people were included in our sample of articles (Table 5). There were 283 *in-vivo* experiments reported in 191 publications (Table 6). Overall, 8414 animals were evaluated in these reports.

Assessment of Completeness of Reporting

We evaluated the completeness of reporting of all 201 *in vivo* preclinical studies and 861 clinical reports (Fig.1B; Table 4). The radar diagrams presented in Fig.3 illustrate the assessed

completeness of reporting for eight distinct study designs against pre-specified reporting guidelines and checklist items. For the 94 RCTs examined (Fig.3A; S10.A), most of the items pertaining to the trial design, methods, and results were reported less than 40% of the time. Study objective(s) and the numbers of participants randomized were reported in 98.9% and 80.9% of trials, respectively. In the 44 non-randomized trials (Fig.3B, S10.B), the items on study objective and numbers of participants allocated were also the most frequently reported (88.6% and 86.4%, respectively). Complete reporting of the remaining checklist items ranged from just 2.3–36.4%.

For the 679 observational studies examined (Fig.3C - 3E; S10.C – S10.E), the study objective(s), some results items, and study conclusions were most frequently reported across designs, with the remaining items tending to be incompletely reported across publications. For the 23 diagnostic accuracy studies examined (Fig.3F), the study objective, participant results, interpretations, and implications had the highest frequency of complete reporting (all >78%). The remaining items were reported in less than half of the studies examined (range: 0.0%-47.8%). For the 21 systematic reviews examined (Fig.3G), with the exception of reporting study design in the title or abstract and providing interpretation in the discussion (76.2% and 66.7%, respectively), most of the items were incompletely reported (e.g. ≤33%).

For the 201 preclinical *in-vivo* studies examined (Fig.3H), there was substantial variability in reporting across checklist items. For example, the title/abstract, objective, and control group were reported in ≥92% of articles. In contrast, blinding, eligibility, and adverse events were reported in <6% of articles.

Discussion

Our results reveal some disturbing findings. Seventeen percent of the articles were based on funded research. The clinical research articles in our sample included more than two million participants; 8414 animals were included in the *in-vivo* publications. Extrapolation across all journals presumed to be predatory, and which publish biomedical research, suggests that more than 52 million humans and animals may have been involved in these publications (Calculation S1). That such a substantial amount of data may never be available for use by others poses major ethical dilemmas. For example, for the nearly 8000 participants who participated in the randomized trials likely did so thinking their participation, while potentially beneficial to them personally, would also contribute to future patients (8). Given that these papers are scientifically weak and difficult to identify, it is not likely that this knowledge will be useful or available to others (9).

Based on our findings, extrapolating to all biomedical research published in these entities, at least 18,000 funded research studies are possibly tucked away in these non-indexed, scientifically questionable journals (Calculation S2), including research supported by NIH (the top funder of research in our sample). To what extent funders know that the work they are funding, often using taxpayer revenues, is being used towards publications in predatory journals, is unknown. A cursory examination of the websites of the 10 most common funders reported in our study identified just one funder (University Grants Commission, India) that provided guidance regarding journal

quality. Researchers have recently summarized the predatory journal situation in India (10). It appears that few funders have explicit policies against the use of their funds towards publication in predatory journals.

The completeness of reporting of selected study types was poor. Particularly deficient were details about study methods, results, and study registration (where assessed). This is wasteful (11). While research published in legitimate journals is not particularly well reported either (12–14) the absolute state of reporting in predatory journals is substantively worse based on our findings. For example, trials published in legitimate journals completely report two 'bias protection' characteristics of randomized trials, sequence generation and allocation concealment, 45% and 30% of the time, respectively (15). In predatory journals, these numbers drop substantially to 23% and 10%, respectively. A recent evaluation of reporting across 300 Medline-indexed systematic reviews found that 70% reported assessing the risk of bias (16), whereas only 9.5% of reviews in this study did so.

Such inadequate reporting in predatory entities is likely the result of several factors, including what appears to be non-existent or very poor peer review and editorial oversight (6). For example, one of the included randomized trials was titled, "Renaissance of Art of Non Descent Vaginal Hysterectomy" (http://bit.ly/2k3LTsj). For this uninformative title (i.e., lacking description of the study's population, interventions, outcomes, and design) to pass peer review and editorial approval suggests that these journals lack a basic understanding of clinical research. While there is no strong evidence to support the effectiveness of peer review (17) we identified numerous examples of what we think amounts to a lack of editorial oversight and/or peer review. One such example is our finding that only 38% of articles mentioned they received approval from an ethics committee. It is unclear how any scientific editor, and ultimately an editor-in-chief, would agree to publish research that has not been ethically approved and fully documented in every publication. Such behavior is outside the recommendations of best practice advocated by international editorial groups, such as the Committee on Publication Ethics.

Limitations

As we set out to complete a descriptive study without a formal hypothesis, we did not calculate a formal sample size for this study. Due to fiscal constraints, we decided *a priori* to include a convenience sample of 25 articles from each included journal. We feel our sample of 1907 articles is large enough for the results to be generalized.

We included case reports and case series in the numerator and denominator of studies reporting ethics information. We recognize that case reports may not require ethics approval and may warrant exclusion from this equation. However, since there is no standard or consensus for whether ethics approval (versus consent) is required for case reports, we decided not to omit case reports or case series from this equation.

The tools we used to categorize study designs may be sub-optimal. There is no single validated tool available for this purpose. Even among experts, study design classification is a complex process (18). For this reason, we carried out a triple-verification process for study design

classification. We did not include every type of research design, particularly from preclinical research, in our evaluation of reporting. Our focus was clinical research because it is potentially most relevant to patient care. We also chose to include *in vivo* animal reports because they often have translational appeal for possible first-in-human experimentation.

We used reporting guideline checklists to rate the completeness of reporting of selected research types. These checklists are not specifically validated for use in this capacity; however, their long-standing use for this purpose makes our research comparable to evaluations of reporting in other studies. Because of the subjective nature of judging the completeness of reporting, we recognize that our findings for this aspect of our study may not be straightforward to reproduce. We also acknowledge that our sample of articles may contain undetected duplicates. As stated, the method of de-duplication was limited due to the nature of predatory journals not being indexed in databases (to our knowledge). We have made our training materials and assessment forms available (https://osf.io/y6hw2/) to enable replication of our methods.

Implications

Recent evidence suggests that predatory journals and publishers are gaining momentum (2) and will continue to pose substantial problems to the legitimate scientific record and elsewhere unless action is taken against them. Funders and academic institutions should consider introducing policies to explicitly direct grantees and prospective authors away from these entities while maintaining their open access mandates. Publications from these entities also pose downstream consequences. Faculty appointment committees and promotion and tenure committees may not be well equipped to detect predatory publications included in CVs. A recent study by Bagues et al., showed that 5% of Italian researchers had presumed predatory publications on their CV's, with an increasing trajectory (19). Some researchers are likely deliberately enhancing the size of their CVs with predatory journal publications, while others likely have more pragmatic reasons (e.g. low APCs), while others may be being duped into submitting. Will predatory journal publications inadvertently contribute to the promotion and tenure of faculty? How will these publications impact grant application committees' assessments? At least one presumed predatory publisher already promotes the fact that they have published work funded by the NIH (http://www.jacobspublishers.com/index.php/nih-article-edition). Will the results of research published in these journals be used to help inform best practice, particularly in jurisdictions where the research was conducted? Perhaps universities working collaboratively with funders should consider developing joint policies and guidance about the hazards of predatory journals and publishers and the need to avoid them all at costs. Such information needs to be displayed prominently on the websites of universities, research institutions, funders, and others.

Availability of Data and Materials

Materials for this project, including the screening and data extraction forms used, and the raw and cleaned data for this study are available on the Open Science Framework (https://osf.io/uydvr/).

Supplementary Materials

There are supplementary tables and calculations in Appendix 2

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Author Information

The authors declare the following competing interests: BH receives consultancy fees from Cornerstone Research Group for methodologic advice related to the conduct of systematic reviews and meta-analysis. Correspondence should be addressed to D.M. (dmoher@ohri.ca).

Tables and Figures

Table 1. Journal Information

Item	Measure	Result
Primary location of journal	Top 5 countries (n, %)[a]	India (19, 32.2%) USA (17, 28.8%) Canada (4, 6.8%) Iran (3, 5.1%) UK, Nigeria, Bulgaria (2, 3.4% each) Not stated (177, 75.0%)
Number of articles available (up to max of 25)	Median (range)	19 (1–25)

[a] Denominator: n = 59 journals

Table 2. Article Demographics[ii]

Item	Measure	Result
Publication Year[iii]	Median (range)	2015 (2009–2016)
Number of Authors	Median (IQR) (range)	4 (3–6) (1–34)
Country of Corresponding or Last author	Top 5 listed (n, %)	India (511, 26.8%) USA (288, 15.1%) Nigeria (99, 5.2%) Iran (82, 4.3%) Japan (75, 3.9%) Not stated (26, 1.4%)
Income Level of Author Country[iv]	High income Upper Middle Income Lower Middle Income Lower Income	725 (38.5%) 342 (18.2%) 788 (41.9%) 26 (1.4%)
Academic Institutions of Corresponding or Last author	Top 5 listed (n, %)	D. Y. Patil University, India (20, 1.0%) Manipal University, India (15, 0.8%) University of Tehran, Iran (14, 0.7%) University of Texas, USA (11, 0.6%) University of Port Harcourt, Nigeria; Harvard University, USA; Bangalore Medical College and Research Institute, India (9, 0.5%) Not stated (15, 0.8%)

[ii] Denominator: n = 1907 (human or animal biomedical research)
[iii] Not reported for 7 articles
[iv] Denominator: n=1881 (articles with author location reported)

Table 3. Ethics and Funding[v]

Item	Measure	Result
Ethics Approval[vi]	Yes (%) No (%) Not reported (%)	724 (39.8%) 17 (0.9%) 1076 (59.2%)
ICD-10	Top 5 (n, %)	Neoplasms (incl. cancers, carcinomas, tumors) (275, 14.4%) Infections and parasitic diseases (231, 12.1%) Endocrine, nutritional, and metabolic disease (178, 9.3%) Circulatory system (161, 8.4%) Nervous system (138, 7.2%)
Funding	Funded (%) Not Funded (%) Not Reported (%)	323 (16.9%) 187 (9.8%) 1397 (73.3%)
Number of Funders	n	345
Funder Name	Top 5 (n, % of articles)	National Institutes of Health, USA (41, 12.7%) University Grants Commission, India (15, 4.6%) Indian council of Medical Research (8, 2.5%) Ministry of Education, Culture, Sports, Science and Technology, Japan; National Natural Science Foundation, China (7, 2.2%) Tehran University of Medical Sciences, Iran (6, 1.9%)
Funder Type	Academic Government Industry Not-for profit Can't tell[vii]	124 (35.9%) 122 (35.4%) 28 (8.1%) 52 (15.1%) 19 (5.5%)

[v] Denominator: n = 1907 (human or animal biomedical research)

[vi] Denominator: n = 1817 (ethics assumed not applicable for systematic reviews (n=21) and cell line work (n=69));

[vii] Not enough information provided or we were unable to determine the type of funder based on a Google search of the funder name and country.

Table 4. Article Type

Item		n (%)
Research Type	Clinical[viii]	1556 (81.6%)
	Preclinical (in vivo)	201 (10.6%)
	Cell or tissue work	150 (7.8%)
Clinical Research Design	Randomized Controlled Trial	94 (6.0%)
	Non-randomized Control Trial	44 (2.8%)
	Cross Sectional	443 (28.5%)
	Observational Cohort	180 (11.6%)
	Case Control	56 (3.6%)
	Diagnostic Accuracy	23 (1.5%)
	Systematic Reviews of Interventions	21 (1.3%)
	Case Report or Series	488 (31.4%)
	Qualitative Research	34 (2.2%)
	Other[ix]	173 (11.1%)

[viii] Primary study or clinical systematic review

[ix] Includes articles reporting more than one study or design (n = 57); and N-of-1 studies, other experimental studies, other observational studies, systematic reviews of observational studies, undetermined designs.

Table 5. Sample Size Calculations and Number of Included Participants

Study Design	Sample size calculation reported	Number of reports	Number of participants
Randomized Controlled Trial[x]	Yes No, but # of participants reported Not reported	26 (27.7%) 68 (72.3%) 0 (0%)	7,780
Non-randomized Controlled Trial	Yes No, but # of participants reported Not reported	7 (15.9%) 36 (81.8%) 1 (2.3%)	5,480
Observational Cohort	Yes No, but # of participants reported Not reported	6 (3.3%) 172 (95.6%) 2 (1.1%)	801,849
Case Control	Yes No, but # of participants reported Not reported	1 (2.0%) 46 (90.2%) 4 (7.8%)	10,483
Cross Sectional	Yes No, but # of participants reported Not reported	40 (9.0%) 386 (87.1%) 17 (3.8%)	1,259,170
Diagnostic Test Accuracy	Yes No, but # of participants reported Not reported	0 23 (100.0%) 0	4048
Systematic Reviews	Number of participants in included studies reported[xi] Not reported, but determined	3 (14.3%) 18 (85.7%)	41,697
Case Report or Series[xii]	(Not collected)		2193
Other[xiii]	(Not collected)		8555
Overall number of participants	n		2,141,255

[x] Proportion of studies reporting sample size calculation

[xi] Sample size calculation not relevant

[xii] based on 487 case reports or series reporting this information

[xiii] based on 155 studies reporting this information

Table 6. Preclincal studies: Number of experiments and animals

Preclinical Studies		
Number of experiments overall	n	283[xiv]
Number of experiments per article	Median (range)	1 (1–18)
Sample size calculation	Yes	3
	No, but # of animals reported	159
	Not reported	39
Number of animals	n	8414[xv]

[xiv] Based on 201 studies reporting this information
[xv] Based on 162 studies reporting sample size of number of animals

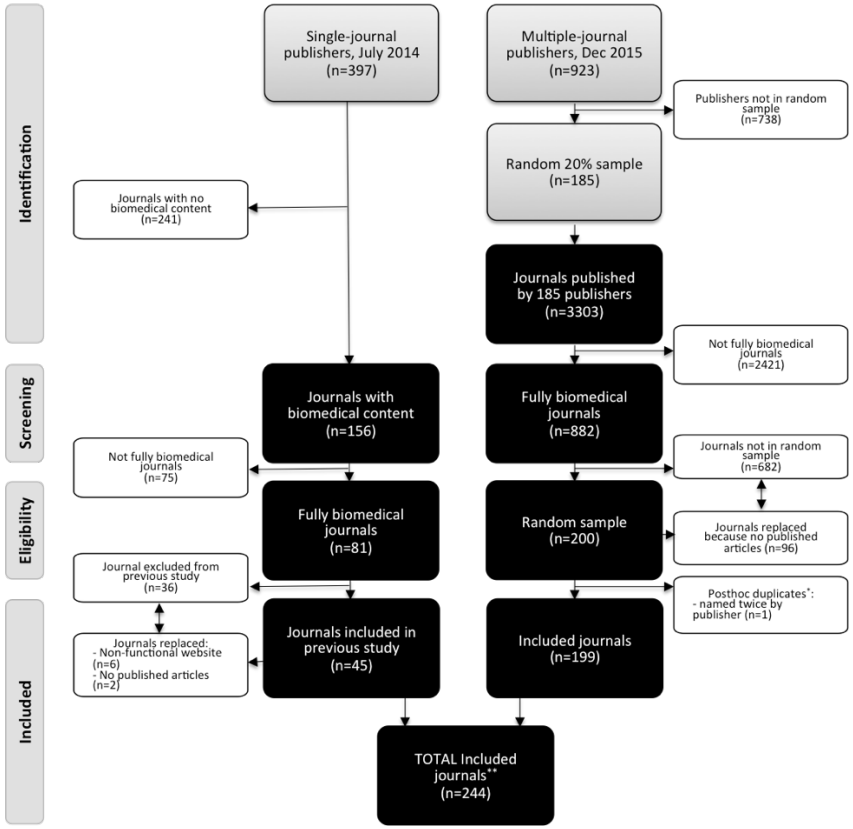


*Fig. 1A. Flow of the publisher (grey) and journal (black) identification and selection process. *contains 44 duplicate journals identified post-hoc due to publishers listing same journal twice on their website (n = 33), and one publisher masking as two separate publishers (i.e., different publisher name, but links to same journals) (n = 11).** 8 journals were excluded (post-hoc) due to duplicate articles identified during data extraction*

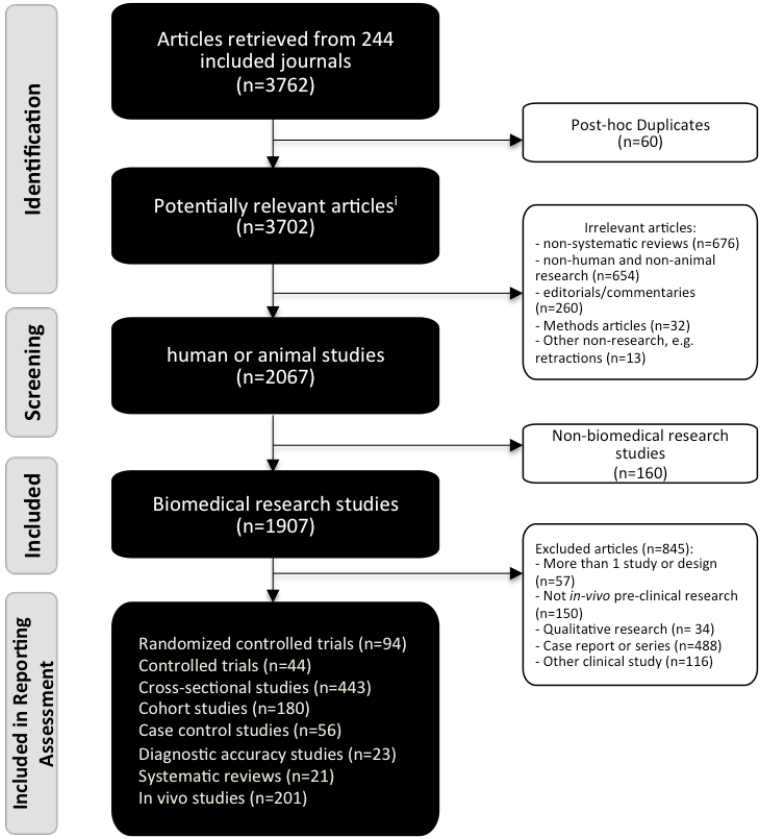


Fig. 1B. Flow of article identification and selection and inclusion in reporting assessment

i 1026 articles obtained from single-journal publishers, 2676 articles obtained from multiple-journal publishers

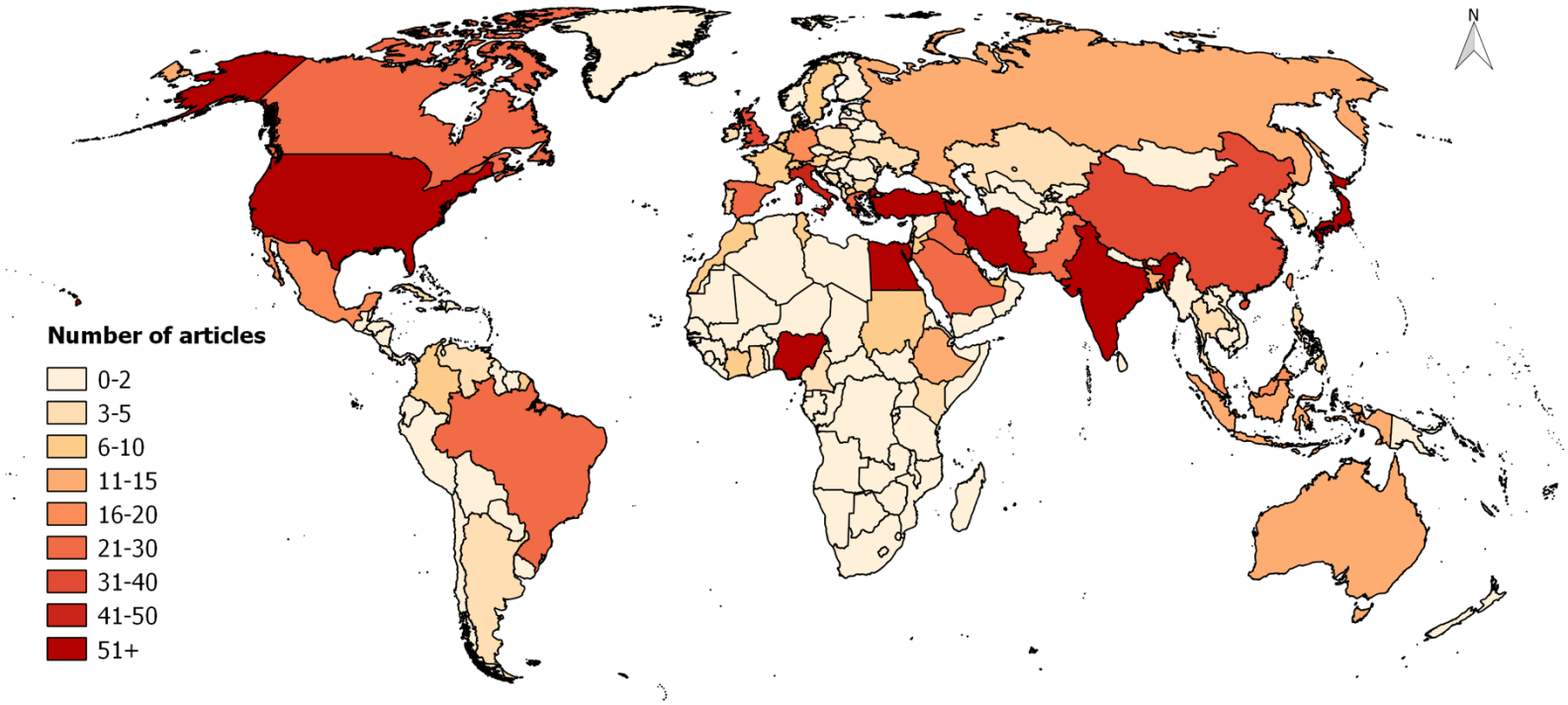
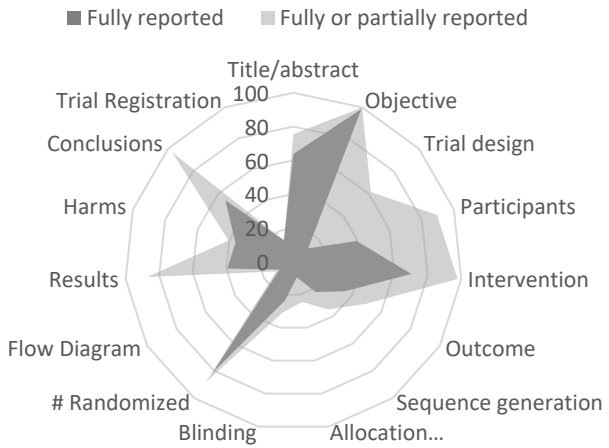
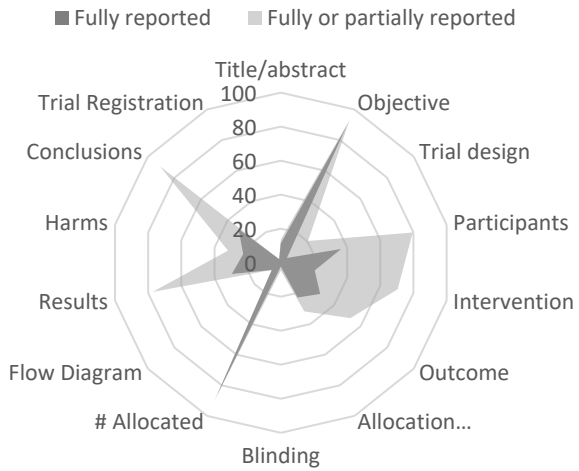


Fig. 2. Country location of corresponding or last author

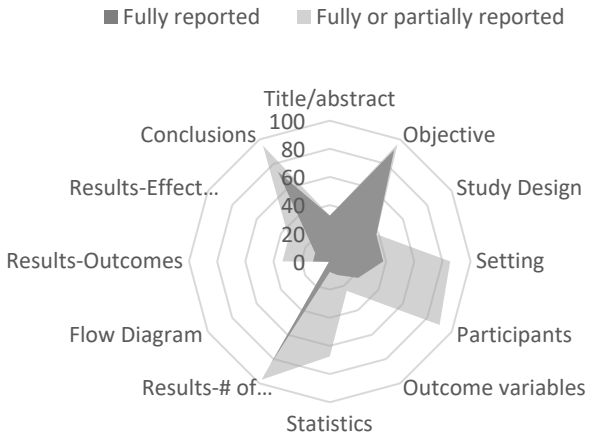
3A. Randomized Controlled Trials (N=94)



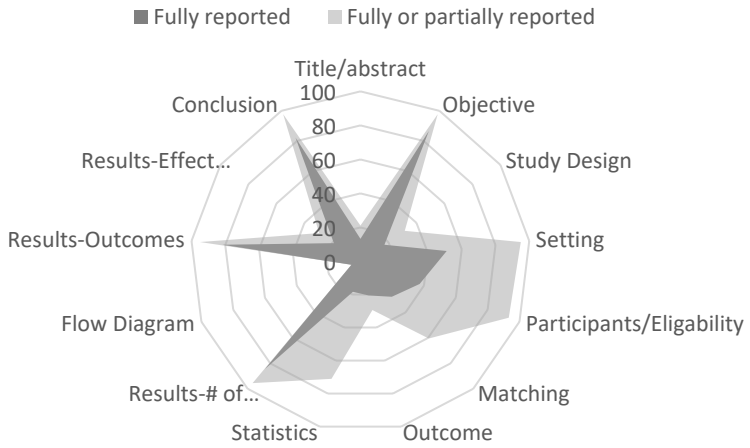
3B. Non-randomized Controlled Trials (N=44)



3C. Cross-Sectional Studies (N=443)



3D. Cohort Studies (N=180)



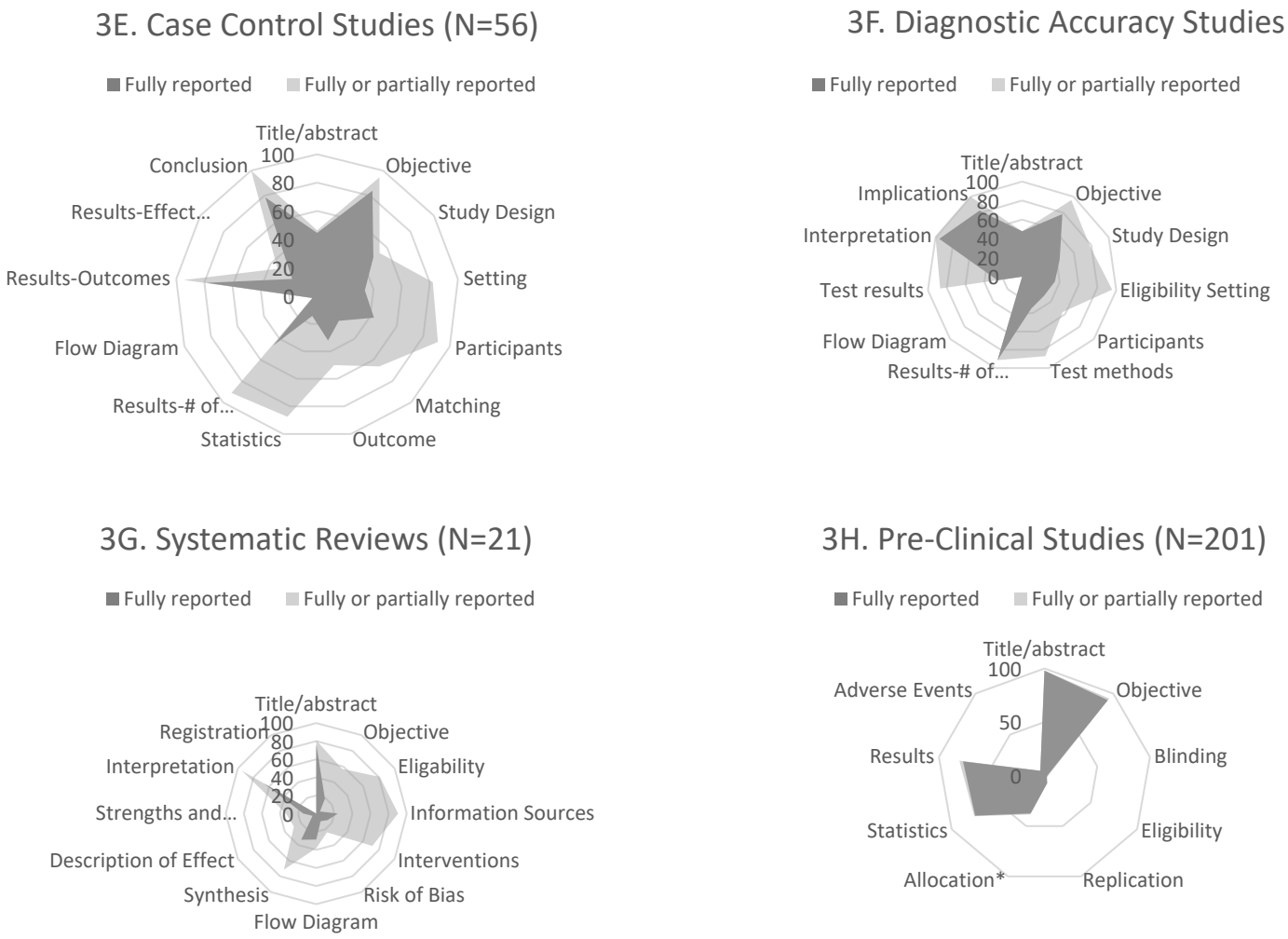


Fig. 3. Frequency of complete reporting for each (modified) reporting guideline item, for each study design group. Both the frequency of 'fully reporting' (dark grey) and 'fully or partially reporting' (light grey) are presented. For details on corresponding reporting items, please see Appendix 2.

References

1. Beall J. Predatory publishers are corrupting open access. Nature. 2012;489:179.

2. Shen C, Bjork B-C, Björk B. 'Predatory' open access: a longitudinal study of article volumes and market characteristics. BMC Med. 2015 Dec 1;13(1):230.

3. Shamseer L, Moher D, Maduekwe O, Turner L, Barbour V, Burch R, et al. Potential predatory and legitimate biomedical journals: can you tell the difference? A cross-sectional comparison. BMC Med. 2017 Dec 16;15(1):28.

4. Clark J, Smith R. Firm action needed on predatory journals. BMJ. 2015 Jan 16;350(jan16 1):h210–h210.

5. Moher D, Moher E. Stop Predatory Publishers Now: Act Collaboratively. Ann Intern Med. 2016 May 3;164(9):616.

6. Bohannon J. Who's afraid of peer review. Science. 2013;342:60–5.

7. Beall J. What I learned from predatory publishers. Biochem Medica. 2017 Jun 15;27(2):273–8.

8. Groves T. Enhancing the quality and transparency of health research. BMJ. 2008 Jul 8;337(jul08 1):a718.

9. Chan A-W, Song F, Vickers A, Jefferson T, Dickersin K, Gøtzsche PC, et al. Increasing value and reducing waste: addressing inaccessible research. Lancet. 2014 Jan;383(9913):257–66.

10. Seethapathy GS, Santhosh Kumar JU, Hareesha AS. India's scientific publication in predatory journals: need for regulating quality of Indian science and education. Curr Sci. 2016;111(11):1759–64.

11. Glasziou P, Altman DG, Bossuyt P, Boutron I, Clarke M, Julious S, et al. Reducing waste from incomplete or unusable reports of biomedical research. Lancet. 2014 Jan;383(9913):267–76.

12. Glasziou P, Meats E, Heneghan C, Shepperd S. What is missing from descriptions of treatment in trials and reviews? BMJ. 2008;336(7659):1472–4.

13. Fung AE, Palanki R, Bakri SJ, Depperschmidt E, Gibson A. Applying the CONSORT and STROBE Statements to Evaluate the Reporting Quality of Neovascular Age-related Macular Degeneration Studies. Ophthalmology. 2009 Feb;116(2):286-296.e4.

14. Hopewell S, Dutton S, Yu L-M, Chan A-W, Altman DG. The quality of reports of randomised trials in 2000 and 2006: comparative study of articles indexed in PubMed. BMJ. 2010 Mar;340(mar23 1):c723.

15. Turner L, Shamseer L, Altman DG, Schulz KF, Moher D. Does use of the CONSORT Statement impact the completeness of reporting of randomised controlled trials published in medical journals? A Cochrane reviewa. Syst Rev. 2012;1(1):60.

16. Page MJ, Shamseer L, Altman DG, Tetzlaff J, Sampson M, Tricco AC, et al. Epidemiology and Reporting Characteristics of Systematic Reviews of Biomedical Research: A Cross-Sectional Study. Low N, editor. PLOS Med. 2016 May 24;13(5):e1002028.

17. Jefferson T, Rudin M, Brodney Folse S, Davidoff F. Editorial peer review for improving the quality of reports of biomedical studies. Cochrane Database Syst Rev. 2007 Apr 18;(2):MR000016.

18. Hartling L, Bond K, Santaguida PL, Viswanathan M, Dryden DM. Testing a tool for the classification of study designs in systematic reviews of interventions and exposures showed moderate reliability and low accuracy. J Clin Epidemiol. 2011;64(8):861–71.

19. Bagues M, Sylos-Labini M, Zinovyeva N. A walk on the wild side: an investigation into the quantity and quality of ' predatory ' publications in Italian academia. LEM Papers Series. Pisa, Italy.: Laboratory of Economics and Management (LEM), Sant'Anna School of Advanced Studies, Pisa, Italy; 2016.

20. Hopewell S, Clarke M, Moher D, Wager E, Middleton P, Altman DG, et al. CONSORT for reporting randomised trials in journal and conference abstracts. Lancet. 2008 Jan;371(9609):281–3.

21. STROBE Group. Draft STROBE checklist for abstracts [Internet]. 2011. Available from: http://www.strobe-statement.org/fileadmin/Strobe/uploads/checklists/STROBE_checklist_conference_abstract_DRAFT.pdf

22. Beller EM, Glasziou PP, Altman DG, Hopewell S, Bastian H, Chalmers I, et al. PRISMA for Abstracts: Reporting Systematic Reviews in Journal and Conference Abstracts. PLoS Med. 2013 Jan;10(4):e1001419.

23. Kilkenny C, Browne WJ, Cuthill IC, Emerson M, Altman DG. Improving bioscience research reporting: the ARRIVE guidelines for reporting animal research. PLoS Biol. 2010 Jan;8(6):e1000412.

24. NIH. Principles and guidelines for reporting preclinical research [Internet]. National Institutes of Health website - About NIH. 2014 [cited 2017 Feb 11]. Available from: http://www.nih.gov/about/reporting-preclinical-research.htm

Appendix 1: Author Contributions

We used ICMJE criteria to determine authorship. DM, LS, and KDC are joint first authors. The study was conceived of by DM, LS, KDC, and JG. DM, LS, KDC, JG, ML, MTA drafted the initial protocol, with input and approval from the vast majority of the STRIP team. LS and KDC managed the research project. All authors carried out the research. LS, KDC, JG, ML, and MTA cleaned the data. LS and KDC analyzed the data, prepared tables and figures, and drafted the methods and results section. DM drafted the initial manuscript, and all authors provided feedback and gave their approval prior to submission.

Contributor Role Taxonomy (CRediT)

#	Role	Author(s)	Definition
1	Conceptualization	DM, LS, KDC, JG	Ideas; formulation or evolution of overarching research goals and aims.
2	Data curation	LS (co-lead), KDC (co-lead), JG, MTA, MML, PB, MG, ASri	Management activities to annotate (produce metadata), scrub data and maintain research data (including software code, where it is necessary for interpreting the data itself) for initial use and later re-use.
3	Formal analysis	KDC, LS	Application of statistical, mathematical, computational, or other formal techniques to analyse or synthesize study data.
4	Funding acquisition	n/a – not funded	Acquisition of the financial support for the project leading to this publication.
5	Investigation	DM, LS, KDC, JG, MML, MTA, NA, MA, PB, AB, RD, RF, MG, CH, MH, BH, II, TAM, MDFM, MJP, MP, KP, BS, ASri, ASte, KT, SVK, RW, DW, FY, AMY, HZ	Conducting a research and investigation process, specifically performing the experiments, or data/evidence collection.
6	Methodology	DM, LS, KDC, JG, MTA, MML	Development or design of methodology; creation of models.
7	Project administration	LS, KDC	Management and coordination responsibility for the research activity planning and execution.
8	Resources	DM	Provision of study materials, reagents, materials, patients, laboratory samples, animals, instrumentation, computing resources, or other analysis tools.

9	Software	n/a	Programming, software development; designing computer programs; implementation of the computer code and supporting algorithms; testing of existing code components.
10	Supervision	DM (co-lead), LS (co-lead), KDC (co-lead), JG, MTA, MML	Oversight and leadership responsibility for the research activity planning and execution, including mentorship external to the core team.
11	Validation	DM (co-lead), LS (co-lead), KDC (co-lead), JG, MTA, MML	Verification, whether as a part of the activity or separate, of the overall replication/reproducibility of results/experiments and other research outputs.
12	Visualization	LS, KDC, MML	Preparation, creation and/or presentation of the published work, specifically visualization/data presentation.
13	Writing – original draft	DM, LS, KDC, MML	Preparation, creation and/or presentation of the published work, specifically writing the initial draft (including substantive translation).
14	Writing – review & editing	DM (co-lead), LS (co-lead), KDC (co-lead), JG, MML, MTA, NA, MA, PB, AB, RD, RF, MG, CH, MH, BH, II, TAM, MDFM, MJP, MP, KP, BS, ASri, ASte, KT, SVK, RW, DW, FY, AMY, HZ	Preparation, creation and/or presentation of the published work by those from the original research group, specifically critical review, commentary or revision – including pre- or post-publication stages.

Appendix 2: Supplementary Tables and Calculations

- Tables S1-S14
- Calculations S1 and S2

Table S1. Reporting guideline checklists used for included study designs

Study design	Reporting Checklist Used
Randomized trial	CONSORT for journal and conference abstracts(20)
Non-randomized trial	CONSORT for journal and conference abstracts(20) (modified)
Case Control	STROBE for journal and conference abstracts (draft version)(21)
Observational Cohort	STROBE for journal and conference abstracts (draft version)(21)
Cross Sectional	STROBE for journal and conference abstracts (draft version)(21)
Diagnostic test Accuracy	STARD for journal and conference abstracts (draft) Bossuyt, P. Draft STARD for abstracts (personal communication). 2016.
Systematic Review or Meta-Analysis	PRISMA for journal and conference abstracts(22)
Preclinical in-vivo	modified selection of items from: ARRIVE reporting guideline checklist(23) and NIH Reproducibility guidelines(24)

Table S2. Randomized controlled trial reporting assessment items

Checklist Item	Yes	No	Partially Reported
Title/abstract: Is the trial described as 'randomized' in the title or abstract?			
Objective: Is the specific objective or hypothesis of the trial stated?			
Trial Design: Is a description of the trial design (e.g. parallel, cluster, non-inferiority), including allocation ratio provided?			
Participants: Are eligibility criteria for participants and the settings where the data were collected described?			
Interventions: Are the interventions for each group, with sufficient details to allow replication, including how and when they were actually administered stated?			
Outcome: Is there a clearly defined primary outcome, including details of how and when it/they were assessed?			
Sequence generation: Is the method used to generate the random allocation sequence described?			
Allocation concealment: Is the mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned, described?			
Blinding (masking): If blinding was done, is there a description of who was blinded after assignment to interventions (for example, participants, care providers, those assessing outcomes) and how? If blinding was not done, is a rationale provided?			
Numbers randomized: Is the number of participants randomized to each group reported?			
Flow Diagram: Is there a flow diagram?			
Outcome: For the primary outcome, is a result for each group as well as the estimated effect size (e.g. the size of the difference between groups) and its precision (such as 95% confidence interval) reported?			
Harms: Are important adverse events or side effects reported or if none are reported, is it mentioned that there were none?			
Conclusions: Is there an interpretation of findings that is consistent with results, balancing benefits and harms, and considering other relevant evidence?			
Trial Registration: Is a registration number and name of the trial register provided?			

Table S3. Non-randomized controlled trial reporting assessment items

Checklist Item	Yes	No	Partially Reported
Title/abstract: Does the title or abstract describe a specific non-randomized study design? (e.g. non-randomized, quasi-experimental, controlled clinical trial, controlled before-after)			
Objective: Is the specific objective or hypothesis of the trial stated?			
Trial Design: Is a description of the trial design (e.g. parallel, cluster, non-inferiority), including allocation ratio provided?			
Participants: Are eligibility criteria for participants and the settings where the data were collected described?			
Interventions: Are the interventions for each group, with sufficient details to allow replication, including how and when they were actually administered stated?			
Outcome: Is there a clearly defined primary outcome, including details of how and when it/they were assessed?			
Sequence generation: Is the method used to generate the non-random allocation sequence described? (e.g. alternation [alternating between two interventions], rotation [cycling through more than two interventions])			
Blinding (masking): If blinding was done, is there a description of who was blinded after assignment to interventions (for example, participants, care providers, those assessing outcomes) and how? If blinding was not done, is a rationale provided?			
Numbers allocated: Is the number of participants assigned to each group reported?			
Flow Diagram: Is there a flow diagram?			
Outcome: For the primary outcome, is a result for each group as well as the estimated effect size (e.g. the size of the difference between groups) and its precision (such as 95% confidence interval) reported?			
Harms: Are important adverse events or side effects reported or if none are reported, is it mentioned that there were none?			
Conclusions: Is there an interpretation of findings that is consistent with results, balancing benefits and harms, and considering other relevant evidence?			
Trial Registration: Is a registration number and name of the trial register provided?			

Table S4. Cross sectional study reporting assessment items

Checklist Item	Yes	No	Partially Reported
Title/abstract: Is the study's design (e.g. cross-sectional) is indicated in the title or abstract?			
Objectives: Are specific objectives or hypothesis stated?			
Study Design: Is there a statement of the study design (e.g. cross-sectional) in the methods section?			
Setting: Is there a description of the study setting, follow-up dates or dates at which the outcome events occurred/were present?			
Participants: Cross-sectional study: Are the i) eligibility criteria, and ii) major sources and methods of selection of participants described?			
Variables: Is there a clearly defined primary outcome/endpoint/dependent variable?			
Statistical methods: Are statistical methods, including those used to control for confounding, described?			
Results - Participants: Are the number of subjects at the beginning AND end of the study reported?			
Flow Diagram: is a flow diagram reported? (may be in an appendix)			
Main Results: Are the numbers of outcome events or summary measures reported for each study group?			
Main Results: Are unadjusted effect estimates (e.g. relative risk) and, if applicable, confounder-adjusted effect estimates and their precision (e.g., 95% confidence intervals) reported?			
Conclusion: Is there a general interpretation of study results referencing study objectives?			

Table S5. Cohort study reporting assessment items

Checklist Item	Yes	No	Partially Reported
Title/abstract: Is the study's design (e.g. cohort) is indicated in the title or abstract?			
Objectives: Are specific objectives or hypothesis stated?			
Study Design: Is there a statement of the study design (e.g cohort) in the methods section?			
Setting: Is there a description of the study setting, follow-up dates or dates at which the outcome events occurred/were present?			
Participants: Cohort study: Are the i) eligibility criteria, ii) the sources and methods of selection of participants, and ii) methods of follow-up described?			
Participants: Cohort study: For matched studies, are matching criteria and the number of exposed (e.g. smoking) and unexposed (non-smoking) subjects reported?			
Variables: Is there a clearly defined primary outcome/endpoint/dependent variable?			
Statistical methods: Are statistical methods, including those used to control for confounding, described?			
Results - Participants: Are the number of subjects at the beginning AND end of the study reported?			
Flow Diagram: is a flow diagram reported? (may be in an appendix)			
Main Results: Are the numbers of outcome events or summary measures over time reported for each study group?			
Main Results: Are unadjusted effect estimates (e.g. relative risk) and, if applicable, confounder-adjusted effect estimates and their precision (e.g., 95% confidence intervals) reported?			
Conclusion: Is there a general interpretation of study results referencing study objectives?			

Table S6. Case control study reporting assessment items

Checklist Item	Yes	No	Partially Reported
Title/abstract: Is the study's design (e.g. case-control) is indicated in the title or abstract?			
Objectives: Are specific objectives or hypothesis stated?			
Study Design: Is there a statement of the study design (e.g. case control) in the methods section?			
Setting: Is there a description of the study setting, follow-up dates or dates at which the outcome events occurred/were present?			
Participants: Case-control: Are the i) eligibility criteria, and ii) the major sources and methods of case ascertainment and control selection described?			
Participants: Case-control study: For matched studies, are matching criteria and the number of controls per case reported?			
Variables: Is there a clearly defined primary outcome/endpoint/dependent variable?			
Statistical methods: Are statistical methods, including those used to control for confounding, described?			
Results - Participants: Are the number of subjects at the beginning AND end of the study reported?			
Flow Diagram: is a flow diagram reported? (may be in an appendix)			
Main Results: Are the numbers in each exposure category (e.g. cancer patients) or summary measures of exposure reported?			
Main Results: Are unadjusted effect estimates (e.g. relative risk) and, if applicable, confounder-adjusted effect estimates and their precision (e.g., 95% confidence intervals) reported?			
Conclusion: Is there a general interpretation of study results referencing study objectives?			

Table S7. Diagnostic accuracy study reporting assessment items

Checklist Item	Yes	No	Partially Reported
Title/abstract: Does the title or abstract indicate that this is a study of diagnostic accuracy using at least one measure of accuracy (such as sensitivity, specificity, predictive values, or area under the ROC curve)?			
Background and Objectives: Are study objectives or hypotheses stated?			
Study Design: Is it clear whether the study is prospective (i.e. data collection was planned before the index test and reference standard were performed) or retrospective (i.e. data collection was planned after the index test and reference standard were performed)?			
Participants: Are i) eligibility criteria for participants and ii) the settings where the data were collected, described?			
Participants: Is it clear whether participants formed a consecutive, random, or convenience series?			
Test methods: Is a replicable description of the index test and reference standard provided? (i.e. enough detail that either can be replicated)			
Results: Are the number of participants with and without the target condition who were included in the analysis, reported?			
Flow diagram: Is there a flow diagram?			
Test Results: Are estimates of diagnostic accuracy (e.g. area under the curve/ROC, likelihood ratios, odds ratios) and their precision (e.g. 95% confidence intervals) reported?			
Discussion: Is there a general interpretation of the results?			
Discussion: Are implications for practice, including the intended use of the index test, described?			

Table S8. Systematic review reporting assessment items

Checklist Item	Yes	No	Partially Reported
Title/abstract: Is this review identified as either: a systematic review, meta-analysis, or both in the title or abstract?			
Objectives: Is there an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS)?			
Eligibility criteria: Are eligibility criteria reported, including the following study characteristics: i) PICOS (study design) ii) length of follow-up; and the following report characteristics: i) years considered, ii) language, iii) publication status?			
Information Sources: Are all information sources included in the search (e.g., databases with dates of coverage, contact with study authors to identify additional studies) and the date last searched reported?			
Risk of bias: Are methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information was used in any data synthesis, described?			
Flow diagram: Is there a flow diagram?			
Synthesis of results: For all outcomes considered (benefits or harms), are simple summary data for each intervention group reported for each study?			
Description of the effect: For all outcomes considered (benefits or harms), are effect estimates and confidence intervals, ideally with a forest plot, reported for each study?			
Strengths and Limitations of evidence: Are the limitations at study and outcome level (e.g., risk of bias), and at review level (e.g., incomplete retrieval of identified research, reporting bias) reported? (or stated that there were none)			
Interpretation: Do the authors report a general interpretation of the results in context of other research and important implications for future research?			
Registration: Is a registration number and registry name reported?			

Table S9. Preclinical (in-vivo) reporting assessment items

If more than 1 in vivo study is reported, please only assess the first one encountered in the methods section.

Checklist Item	Yes	No	Partially Reported
Title/abstract: Does the title or abstract indicate that this is a non-human animal study?			
Objective: Are the study objectives/hypotheses clearly stated?			
Blinding: Is it clear whether the following groups were blinded: experimenters and/or caregivers, outcome assessors, or those analysing data?			
Eligibility Criteria: Are inclusion/exclusion criteria for data/samples/subjects clearly stated?			
Replication: Is replication, reproduction, or repetition of in vivo experiments (e.g. done multiple times) described?			
Were control and experimental groups used in this experiment?			
If Yes to above: Allocation: was the method of allocation to groups, including randomization, stated?			
Statistical Analyses: Are details of the statistical methods used for each analysis provided?			
First Result: Were summary estimates (e.g measures of central tendency), for each group, if applicable, with measures of variance (e.g. error bars defined as SD, SEM, or CI) reported for the first reported in vivo result/outcome in the results section?			
Adverse Events: Were any adverse events described (or was it stated that there were none)?			

Table S10.A-H. Reporting assessment summary data for the eight designs assessed.

A. Reporting assessment of randomized controlled trials

Item	Is the item reported?			Total	% yes	% yes and partial
	No	Partial	Yes			
Title/abstract	23	11	60	94	63.8	75.5
Objective	0	1	93	94	98.9	100.0
Trial design	36	47	11	94	11.7	61.7
Participants	10	47	37	94	39.4	89.4
Intervention	2	26	66	94	70.2	97.9
Outcome	47	14	33	94	35.1	50.0
Sequence	61	12	21	94	22.3	35.1
Allocation	71	14	9	94	9.6	24.5
Blinding	65	7	22	94	23.4	30.9
# Randomized	11	7	76	94	80.9	88.3
Flow Diagram	83	2	9	94	9.6	11.7
Results	12	45	37	94	39.4	87.2
Harms	56	4	34	94	36.2	40.4
Conclusions	3	40	51	94	54.3	96.8
Trail Registration	81	0	13	94	13.8	13.8

B. Reporting assessment of non-randomized trials

Item	Is the item reported?			Total	% yes	% yes and partial
	No	Partial	Yes			
Title/abstract	38	1	5	44	11.4	13.6
Objective	3	2	39	44	88.6	93.2
Trial design	35	7	2	44	4.5	20.5
Participants	9	19	16	44	36.4	79.5
Intervention	13	22	9	44	20.5	70.5
Outcome	21	10	13	44	29.5	52.3
Allocation	30	4	10	44	22.7	31.8
Blinding	42	1	1	44	2.3	4.5
# Allocated	4	2	38	44	86.4	90.9
Flow Diagram	41	0	3	44	6.8	6.8
Results	10	21	13	44	29.5	77.3
Harms	30	4	10	44	22.7	31.8
Conclusions	4	26	14	44	31.8	90.9
Trail Registration	43	0	1	44	2.3	2.3

C. Reporting assessment of cross-sectional studies

Item	Is the item reported?			Total	% yes	% yes and partial
	No	Partial	Yes			
Title/abstract	299	0	144	443	32.5	32.5
Objective	17	21	405	443	91.4	96.2
Study Design	272	2	169	443	38.1	38.6
Setting	64	211	168	443	37.9	85.6
Participants	44	296	103	443	23.3	90.1
Outcome variables	336	58	49	443	11.1	24.2
Statistics	144	266	33	443	7.4	67.5
Results-Participants	13	57	373	443	84.2	97.1
Flow Diagram	440	0	3	443	0.7	0.7
Results-Outcomes	294	96	53	443	12.0	33.6
Results-Effect Estimates	294	96	53	443	12.0	33.6
Conclusions	22	95	326	443	73.6	95.0

D. Reporting assessment of cohort studies

Item	Is the item reported?			Total	% yes	%yes and partial
	No	Partial	Yes			
Title/abstract	142	14	24	180	13.3	21.1
Objective	4	20	156	180	86.7	97.8
Study Design	123	26	31	180	17.2	31.7
Setting	9	79	92	180	51.1	95.0
Participants/Eligibility	12	101	67	180	37.2	93.3
Matching	71	59	50	180	27.8	60.6
Outcome	127	16	37	180	20.6	29.4
Statistics	52	95	33	180	18.3	71.1
Results-Participants	8	20	152	180	84.4	95.6
Flow Diagram	170	0	10	180	5.6	5.6
Results Outcomes	9	24	147	180	81.7	95.0
Results-Effect Estimates	127	19	34	180	18.9	29.4
Conclusion	4	28	148	180	82.2	97.8

E. Reporting assessment of case control studies

Item	Is the item reported?			Total	% yes	% yes and partial
	No	Partial	Yes			
Title/abstract	30	1	25	56	44.6	46.4
Objective	3	6	47	56	83.9	94.6
Study Design	26	3	27	56	48.2	53.6
Setting	10	27	19	56	33.9	82.1
Participants	5	27	24	56	42.9	91.1
Matching	19	24	13	56	23.2	66.1
Outcome	28	10	18	56	32.1	50.0
Statistics	7	41	8	56	14.3	87.5
Results-Participants	5	25	26	56	46.4	91.1
Flow Diagram	54	0	2	56	3.6	3.6
Results Exposures	3	9	44	56	78.6	94.6
Results -Effect Estimates	37	7	12	56	21.4	33.9
Conclusion	0	12	44	56	78.6	100.0

F. Reporting assessment of systematic reviews

Item	Is the item reported?			Total	% yes	% yes and partial
	No	Partial	Yes			
Title/abstract	4	1	16	21	76.2	81.0
Objective	9	8	4	21	19.0	57.1
Eligibility	4	16	1	21	4.8	81.0
Information Sources	2	14	5	21	23.8	90.5
Interventions	6	12	3	21	14.3	71.4
Risk of Bias	16	3	2	21	9.5	23.8
Flow Diagram	13	2	6	21	28.6	38.1
Synthesis	6	8	7	21	33.3	71.4
Description of Effect	15	5	1	21	4.8	28.6
Strengths and Limitations of Effect	14	4	3	21	14.3	33.3
Interpretation	1	6	14	21	66.7	95.2
Registration	21	0	0	21	0.0	0.0

G. Reporting assessment of diagnostic accuracy studies

Item	Is the item reported?			Total	% yes	% yes and partial
	No	Partial	Yes			
Title/abstract	12	0	11	23	47.8	47.8
Objective	1	4	18	23	78.3	95.7
Study Design	5	8	10	23	43.5	78.3
Eligibility Setting	1	14	8	23	34.8	95.7
Participants	10	6	7	23	30.4	56.5
Test methods	3	12	8	23	34.8	87.0
Results- Participants	2	0	21	23	91.3	91.3
Flow Diagram	23	0	0	23	0.0	0.0
Test results	3	14	6	23	26.1	87.0
Interpretation	0	1	22	23	95.7	100.0
Implications	0	4	19	23	82.6	100.0

H. Reporting assessment of preclinical studies

Item	Is the item reported?			Total	% yes	% yes and partial
	No	Partial	Yes			
Title/abstract	4	0	197	201	98.0	98.0
Objective	12	4	185	201	92.0	94.0
Blinding	193	2	6	201	3.0	4.0
Eligibility	195	1	5	201	2.5	3.0
Replication	186	0	15	201	7.5	7.5
Allocation i	118	2	72	192	37.5	38.5
Statistics	49	2	150	201	74.6	75.6
Results	39	7	155	201	77.1	80.6
Adverse Events	189	0	12	201	6.0	6.0

[i] Only relevant for 192 studies in which a control group was used

Table S11: Journals publishing US-affiliated authors (Nature requested)

Reference Number and Journal Name	Freq	%
185_012_40 Journal of Surgery	13	4.51
2229_153_34 The Open Neuroimaging Journal	11	3.82
181_012_36 Journal of Pediatrics & Child Care	8	2.78
840_050_03 American Journal of Cancer	8	2.78
176_012_31 Journal of Ocular Biology	7	2.43
1963_136_01 Journal of Clinical Medicine Research	7	2.43
2232_153_37 The Open Nutrition Journal	7	2.43
1967_136_05 World Journal of Nephrology and Urology	6	2.08
1970_136_08 Cardiology Research	6	2.08
791_048_18 Jacobs Journal of Gynecology and Obstetrics	6	2.08
147_012_02 International Journal of Otorhinolaryngology	5	1.74
2225_153_30 The Open Medical Informatics Journal	5	1.74
586_021_08 Diabetes Research	5	1.74
596_021_18 Neuro	5	1.74
776_048_03 Jacobs Journal of Allergy and Immunology	5	1.74
790_048_17 Jacobs Journal of Gerontology	5	1.74
803_048_30 Jacobs Journal of Otolaryngology	5	1.74
1243_083_22 Neonatology & Clinical Pediatrics	4	1.39
157_012_12 Journal of Clinical & Medical Case Reports	4	1.39
1639_107_09 Gastroenterology & Hepatology: Open Access	4	1.39
1648_107_18 Journal of Psychology & Clinical Psychiatry	4	1.39
1667_107_37 Hematology & Transfusion International Journal	4	1.39
182_012_37 Journal of Pharmaceutics & Pharmacology	4	1.39
2171_152_13 Heart Health	4	1.39
2175_152_17 International Journal of Cancer Research and Molecular Mechanisms	4	1.39
2227_153_32 Open Medicine Journal	4	1.39
781_048_08 Jacobs Journal of Clinical Case Reports	4	1.39
785_048_12 Jacobs Journal of Emergency Medicine	4	1.39
811_048_38 Jacobs Journal of Sports Medicine	4	1.39
995_069_13 Journal of Cancer Science & Therapy (JCST)	4	1.39
1076_074_11 Obesity & Control Therapies: Open Access	3	1.04
1260_083_39 Obesity & Weight Loss	3	1.04
150_012_05 Journal of Andrology & Gynaecology	3	1.04
1646_107_16 Advances in Obesity, Weight Management & Control	3	1.04
177_012_32 Journal of Oncobiomarkers	3	1.04
179_012_34 Journal of Orthopedics & Rheumatology	3	1.04
2176_152_18 International Journal of Dentistry and Oral Health	3	1.04
2177_152_19 International Journal of Endocrinology and Metabolic Disorders	3	1.04
2193_152_35 Surgery: Open Access	3	1.04
612_021_34 Surgical Research	3	1.04
778_048_05 Jacobs Journal of Anesthesiology and Research	3	1.04
798_048_025 Jacobs Journal of Neurology and Neuroscience	3	1.04

Reference Number and Journal Name	Freq	%
808_048_35 Jacobs Journal of Pulmonology	3	1.04
812_048_39 Jacobs Journal of Surgery	3	1.04
1228_083_07 Anesthesia & Clinical care	2	0.69
1296_088_04 Athens Journal of Health	2	0.69
154_012_09 Journal of Cancer Sciences..	2	0.69
1671_107_41 MOJ Addiction Medicine & Therapy	2	0.69
170_012_25 Journal of Integrative Medicine & Therapy	2	0.69
1846_125_01 Neurological Research and Therapy: Open Access	2	0.69
190_012_45 Journal of Vaccine & Immunotechnology	2	0.69
1921_128_7 Open Journal of Pharmacology	2	0.69
1965_136_03 Journal of Neurology Research	2	0.69
2170_152_12 Gastric Disorders and Therapy	2	0.69
2205_153_10 The Open Cardiovascular Medicine Journal	2	0.69
2458_159_02 Archive of Neuroscience	2	0.69
2720_168_25 International Journal of Cancer Research	2	0.69
4013_213_01 International Journal of Health Research	2	0.69
4031_231_01 Journal of Medical Research and Practice	2	0.69
590_021_12 Gynecology and Obstetrics Research	2	0.69
774_048_01 Jacobs Journal of Addiction and Therapy	2	0.69
792_048_19 Jacobs Journal of Hematology	2	0.69
7_003_4 Advances in Modern Oncology Research	2	0.69
801_048_28 Jacobs Journal of Ophthalmology	2	0.69
802_048_29 Jacobs Journal of Orthopedics and Rheumatology	2	0.69
842_050_05 American Journal of Cancer Biology	2	0.69
917_054_03 Journal Of Advances In Allergy & Immunologic Diseases	2	0.69
988_069_06 Journal of Glycomics & Lipidomics (JGL)	2	0.69
993_069_11 Journal of Bioanalysis & Biomedicine (JBABM)	2	0.69
1061_073_15 International Journal of Advanced Nursing Studies	1	0.35
1099_074_34 SOJ Microbiology & Infectious Diseases	1	0.35
1222_083_01 Infectious & Non Infectious Diseases	1	0.35
1229_083_08 AIDS Clinical Research & STDs	1	0.35
1230_083_09 Cancer Biology and Treatment	1	0.35
1257_083_36 Nephrology & Renal Therapy	1	0.35
1258_083_37 Otolaryngology, Head & Neck Surgery	1	0.35
1644_107_14 MOJ Orthopedics & Rheumatology	1	0.35
1690_107_60 MOJ Women's Health	1	0.35
1755_111_34 International Journal of Clinical Medicine Research	1	0.35
180_012_35 Journal of Parkinson’s disease and Alzheimer's disease	1	0.35
1848_125_03 Heart Health : Open Access	1	0.35
1858_125_13 Clinical Research and Development : Open Access	1	0.35
1877_125_32 Aperito Journal of Oral Health and Dentistry	1	0.35
188_012_43 Journal of Transplantation & Stem Cell Biology	1	0.35
2164_152_06 Clinical Anesthesia and Management	1	0.35

Reference Number and Journal Name	Freq	%
2169_152_11 Epidemiology and Public Health Reviews	1	0.35
2181_152_23 International Journal of Nephrology and Kidney Failure	1	0.35
2194_152_36 Transplantation Research Journal	1	0.35
2457_159_01 Anesthesiology and Pain Medicine	1	0.35
3343_183_06 JOURNAL OF MULTIDISCIPLINARY PATHOLOGY	1	0.35
4003_203_01 Global Journal of Medicine and Public Health	1	0.35
4012_212_01 International Journal of Drug Development and Research	1	0.35
4016_216_01 International Journal of Medical Research & Health Sciences	1	0.35
601_021_23 Otolaryngology - Open Journal (OTLOJ)	1	0.35
608_021_30 Pulmonary Research and Respiratory Medicine	1	0.35
799_048_26 Jacobs Journal of Nursing and Care	1	0.35
813_048_40 Jacobs Journal of Vaccines and Vaccination	1	0.35
986_069_04 Journal of Antivirals & Antiretrovirals (JAA)	1	0.35
987_069_05 Journal of Data Mining in Genomics & Proteomics (JDMGP)	1	0.35
TOTAL	288	

Table S12: Journals publishing NIH–funded studies (Nature requested)

Number of articles	Journal Name
4	International Journal of Cancer Research and Molecular Mechanisms
4	Journal of Cancer Science & Therapy (JCST)
3	The Open Neuroimaging Journal
2	World Journal of Nephrology and Urology
2	Open Medicine Journal
2	Diabetes Research
2	Jacobs Journal of Allergy and Immunology
1	Control Therapies: Open Access
1	SOJ Microbiology & Infectious Diseases
1	International Journal of Otorhinolaryngology
1	Journal of Integrative Medicine & Therapy
1	Journal of Ocular Biology
1	Journal of Orthopedics & Rheumatology
1	Journal of Health, Medicine and Nursing
1	182_012_37 Journal of Pharmaceutics & Pharmacology
1	Journal of Vaccine & Immunotechnology
1	Open Journal of Pharmacology
1	The Open Medical Informatics Journal
1	The Open Nutrition Journal
1	Archive of Neuroscience
1	Neuro
1	Advances in Modern Oncology Research
1	Jacobs Journal of Addiction and Therapy
1	Jacobs Journal of Anesthesiology and Research
1	Jacobs Journal of Ophthalmology
1	American Journal of Cancer Biology
1	Journal of Antivirals & Antiretrovirals (JAA)
1	Journal of Data Mining in Genomics & Proteomics (JDMGP)
1	Journal of Glycomics & Lipidomics (JGL)

Table S13: Number of publications by authors from select top institutions (Nature requested)

University	Number of authors	Number of publications	Description of occurrences
D. Y. Patil University	14	20	1 author published 6 unique articles (4 in the same journal: International Journal of Medical and Clinical Research); 2 authors published two unique articles each; 10 authors published 1 unique article each
University of Tehran	14	14	14 authors published 1 unique article each
University of Texas	8	11	1 author published 3 unique articles in a single journal: Journal of Pediatrics & Child Care; 7 authors published 1 unique article each
Harvard University	7	9	2 authors published 2 unique articles each in: The Open Neuroimaging Journal and Journal of Surgery; 5 authors published 1 unique article each

Table S14: Number of duplicate authors in sample (Nature requested)

Number of articles with same author name/email address	Number of occurrences
2	85
3	21
4	6
5	2
6	1

Calculation S1. Estimation of the number of human and animal participants reported in biomedical studies published in predatory journals.

The calculations below are based on the 2017 estimations of predatory journals provided on a blog by Jeffrey Beall: https://scholarlyoa.com/2017/01/03/bealls-list-of-predatory-publishers-2017/. We have provided a screenshot of those numbers below:

Potential, possible, or probable predatory scholarly open-access journals: This year, 2017, marks the fifth annual release of this list, which is also continuously updated. The list this year includes 1294 journals, an increase of 412 over 2016. This is the first year that the number of standalone journals is higher than the number of publishers.

Standalone journals	
Year	Number of journals
2013	126
2014	303
2015	507
2016	882
2017	1294

Number of predatory, standalone journals, 2013-2017.

Potential, possible, or probable predatory scholarly open-access publishers: This year, 2017, marks the seventh annual release or announcement of this list, which is also continuously updated. The list this year includes 1155 publishers, an increase of 232 over 2016. There are now over one thousand predatory open-access publishers.

Publishers	
Year	Number of publishers
2011	18
2012	23
2013	225
2014	477
2015	693
2016	923
2017	1155

Number of predatory publishers, 2011-2017.

Estimation of the number of biomedical predatory journals (2017)

	single journal publishers	multiple journal publishers
Number of biomedical journals	81	882 x 5 = 4,410
Number of journals in sample	397	3,303 x 5 = 16,515
% biomed journals	20.40%	26.70%
Average number of journals/publisher	1	16,515 journals /923 publishers = 17.89
Number of publishers (2017 estimate)	1294	1155
Number of journals (2017 estimate)	1,294 publishers x 1 journal = 1,294	1,155 publishers x 17.89 journals = 20663
Number of biomed journals (2017 estimate)	20.40% x 1,294 publishers = 264	26.70% x 20663 = 5,517

Estimation of the number of participants included in biomedical research published in biomedical predatory journals.

Number of participants in biomed research/journal (single and multiple combined)	2,141,255 humans 8,414 animals = 2,149,669
Number of journals in our sample (excluding duplicates)	236
% of participants/journal	2,149,669/236 = 9,109
Potential number of participants in active journals[16] publishing at least 19 articles	9,109 x 70% x (264+5,517) = 36,860,446

Calculation S2. Estimation of the number of funded studies in biomedical predatory journals

Number of biomed journals (2017 estimate)	264 + 5,517 = 5,781
Average number of articles/journal	19
Number of articles across biomedical predatory journals	19 x 5,781 = 109,839
Proportion of studies receiving funding/journal	17%
Number of funded biomedical studies	109,839 x 0.17 = 18,673

[16] 30% of biomedical journals sampled had no content

Appendix 3: Published Article

COMMENT

ILLUSTRATION BY DAVID PARKINS

Stop this waste of people, animals and money

Predatory journals have shoddy reporting and include papers from wealthy nations, find **David Moher, Larissa Shamseer, Kelly Cobey** and colleagues.

Predatory journals are easy to please. They seem to accept papers with little regard for quality, at a fraction of the cost charged by mainstream open-access journals. These supposedly scholarly publishing entities are murky operations, making money by collecting fees while failing to deliver on their claims of being open access and failing to provide services such as peer review and archiving.

Despite abundant evidence that the bar is low, not much is known about who publishes in this shady realm, and what the papers are like. Common wisdom assumes that the hazard of predatory publishing is restricted mainly to the developing world. In one famous sting, a journalist for *Science* sent a purposely flawed paper to 140 presumed predatory titles (and to a roughly equal number of other open-access titles), pretending to be a biologist based in African capital cities[1]. At least two earlier, smaller surveys found that most authors were in India or elsewhere in Asia[2,3]. A campaign to warn scholars about predatory journals has concentrated its efforts in Africa, China, India, the Middle East and Russia. Frequent, aggressive solicitations from predatory publishers are generally considered merely a nuisance for scientists from rich countries, not a threat to scholarly integrity.

Our evidence disputes this view. We spent 12 months rigorously characterizing nearly 2,000 biomedical articles from more than 200 journals thought likely to be predatory. More than half of the corresponding authors hailed from high- and upper-middle-income countries as defined by the World Bank.

Of the 17% of sampled articles that reported a funding source, the most frequently named funder was the US National Institutes of Health (NIH). The United States produced more articles in our sample than all other countries save India. Harvard University (with 9 articles) in Cambridge, Massachusetts, and the University of Texas (with ▶

11 articles across all campuses) were among the eight institutions with the most articles. It is easy to imagine other, similar institutions coming up in a different sample. The point is, the problem of predatory journals is more urgent than many realize.

Articles in our sample consistently failed to report key information necessary for readers to assess, reproduce and build on the findings. Fewer than 10% of studies claiming to be randomized controlled trials described how patients were allocated to treatment groups; where blinding was possible, fewer than one-quarter noted whether patients and outcome assessors were blinded to group assignment.

Whether authors are being duped or are overzealously seeking to lengthen their publication lists, this represents enormous waste. Just the subset of articles that we examined contained data from more than 2 million individuals and over 8,000 animals. By extrapolation, we estimate that at least 18,000 funded biomedical-research studies are tucked away in poorly indexed, scientifically questionable journals. Little of this work will advance science. It is too dodgily reported (and possibly badly conducted) and too hard to find.

In our view, publishing in predatory journals is unethical. Individuals who agree to be studied expect that their participation could benefit future patients. Use of animals in biomedical research is rationalized on the assumption that experiments will contribute valuable information. Even assuming authors are publishing more than one paper from their study (and some are), they should be held to a higher standard of disclosure. Publishers, funders and research institutions must join together to prevent research from ending up in predatory journals.

WHAT WE DID

We drew our sample from the journals and publishers whose status as predatory was deemed as "potential, possible, or probable" by librarian Jeffrey Beall of the University of Colorado, Denver. (These controversial compilations were taken offline early in 2017, but remain available in web archives and are one of the few tools that researchers have to investigate illegitimate journals.)

We took a random subset of 185 publishers and obtained lists of their journals. At least two people, working independently, assessed whether each journal met Medline's selection criteria as having a biomedical scope. We randomly selected 200 journals from this list; we also included 45 biomedical standalone journals from a set that had been developed similarly for another study[4].

In February 2016, we visited each journal's website and downloaded copies of up to 25 articles, starting with the ones most recently published. The total number of articles we obtained came to 3,702, because many journals listed fewer than 25 articles. Of those, 1,907 reported primary biomedical research or systematic reviews and so were included in our analysis. This left us with 41 single-journal publishers and 179 titles from 51 multi-journal publishers (see Supplementary information and https://osf.io/r2gj6/).

SLOPPY WORK

We examined each paper in light of reporting guidelines relevant for each type of study. For example, for randomized controlled trials, we cross-checked articles using a modified Consolidated Standards of Reporting Trials (CONSORT) checklist.

Although adherence to and enforcement of guidelines is patchy even in mainstream publications, reporting quality in our sample was much worse. Articles were particularly deficient in descriptions of study methods, results and — for clinical trials and systematic reviews — study registration. Of the 94 randomized controlled trials that we examined, most items in CONSORT were reported 40% of the time. Fewer than 14% of trials gave a registration number or registry name. Yet, a study of mainstream journals in the Netherlands found registration information in at least 60% of trials[5].

"In our view, publishing in predatory journals is unethical."

Of the 21 systematic reviews in our sample, only two reported assessing the risk of bias. Yet 70% did so in an evaluation of 300 Medline-indexed systematic reviews[6]. Even for animal studies, for which reporting in mainstream journals is remarkably poor, we found that performance of predatory journals was much worse; for instance, just 3% of 201 relevant predatory articles reported blinding. A separate study found that blinding is recorded in 20% of articles in PLoS journals and in 21% of articles in Nature journals[7].

Of the articles in our sample that evaluated humans or whole animals, only 40% noted that they received approval from an ethics committee. Previous studies show that ethics-committee approval is mentioned in more than 90% of animal[7] and 70% of human[8] studies published in mainstream journals.

GLOBAL PROBLEM

Nearly three-quarters (1,397) of the publications we examined did not report information about funding; 10% stated that they were not funded. The remaining 323 articles named 345 different funders, mainly academic institutions (124) and government agencies (122).

For 1,907 papers, corresponding authors came from 103 countries, including India (27%), the United States (15%), Nigeria (5%), Iran (4%) and Japan (4%) (see 'Global predation'). These figures should be interpreted in the context of total scientific output per nation. According to rates in the academic databases Scopus and PubMed, the United States produced about 5 times as many biomedical articles as India last year, and 80 times as many as Nigeria. An analysis of general academic articles from 2013 to 2015 in Scopus found that 10% or more from India and Nigeria were in predatory journals, as compared to less than 1% from Japan and the United States[9].

Researchers at universities in Indiana also looked at who has published in predatory pharmaceutical journals in 2013 (ref. 2). They compared authors who published in seven predatory titles on Beall's list with those in five open-access journals that rejected the journalist's bait in the sting operation[1]. Sixty-five per cent of authors of predatory-journal articles had never published before, as compared to 19% of those in vetted open-access journals. In that study, 75% of all authors in predatory journals were from South Asia (mainly India), 14% from Africa (mainly Nigeria) and only 3% from North America. By contrast, 57% of authors in our sample are from higher-income or upper-middle-income countries.

This could be because our sampling looked mainly at corresponding authors rather than all authors, or because it considered a broader swath of articles, titles and years. It is possible that our sample included some journals particularly popular with high-income-country authors. Or, perhaps, predatory journals have stepped up their aggressive e-mails in richer countries.

Corresponding authors in our survey named 1,291 institutions as primary affiliations; 15 did not name any. We contacted 16 vice-presidents (or the senior administrative person) of research at some of the top institutions whose researchers were publishing in predatory journals. Our e-mail to Bangalore Medical College and Research Institute bounced back. Three institutions provided feedback; one (Manipal University, India, 15 papers) detailed an intervention launched earlier this year, and provided data that the effort reduced the number of articles published in presumed predatory journals.

Responses from the University of Benin in Nigeria (8 papers) and Menoufia University in Egypt (8 papers) said that they warned against or made lists of illegitimate publishers for researchers to consult. The Mayo Clinic in Rochester, Minnesota (7 papers), sent a note to *Nature* that articles in predatory journals are not considered for academic advancement. D. Y. Patil University in India, which, with 20 papers, had the most in our sample, did not reply. Nor did the University of Tehran, which, with 14 papers from 14 authors, tied with D. Y. Patil University for the most unique authors.

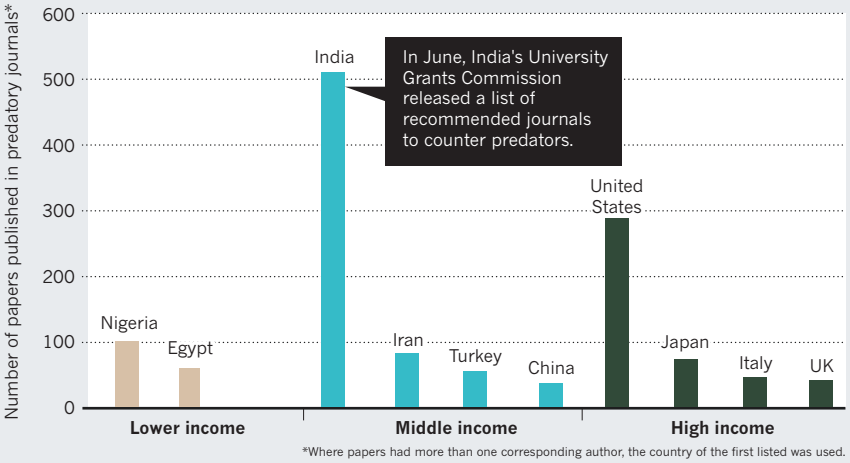
We also attempted to contact corresponding authors at some of the leading institutions. Fifteen articles — including all 9 at Bangalore

SOURCE: STUDY REPORTING IN PREDATORY JOURNALS GROUP

GLOBAL PREDATION

A sample of 1,907 papers in more than 200 supposed predatory journals found that most of the articles come from India. Surprisingly, however, more than half of the papers have authors from higher-income or upper-middle-income countries.

Predatory papers by country and income



*Where papers had more than one corresponding author, the country of the first listed was used.

Medical College and Research Institute — did not include author e-mails. In total, we sent e-mails to 87 authors (who had collectively written 119 of the articles in our sample). Three bounced back. Of the 18 replies we received, 3 asked for educational material about predatory journals. Only two said that they were aware of the journal's categorization as potentially predatory, and only four were aware of Beall's list. Similarly, 90% of 1,088 Italian authors surveyed in 2016 stated that they were unaware of Beall's list (see go.nature.com/2ixzvqm).

Only three people who responded to us had submitted their manuscript to other publications before its acceptance in the predatory journal. Seven indicated receiving guidance of some form on where to submit; an equal number said that their work had been cited. This suggests that authors are not using these titles as a last resort: the scientific community needs a better understanding of what precisely makes predatory journals attractive.

Although, collectively, the articles we examined were atrocious in terms of reporting, we did not examine the performance of individual titles. We should note that several publishers have protested against their inclusion on Beall's list. Also, the term 'predator' in particular is questioned, because on occasion it is hard to tell whether a journal is simply inept or disdaining research integrity and scientific robustness to pursue profit. And rather than being prey, some authors may purposely seek out low-barrier ways to publish.

Some may argue that authors in higher-income countries publish in the 'best' predatory journals. Our study was not set up to resolve this question; we did examine reporting of randomization and allocation across the 94 clinical trials, and found no statistical differences between rich-world corresponding authors and those from elsewhere.

It is nearly impossible for prospective authors to differentiate predatory journals by metrics. For example, the *Journal of Surgery* from Avens Publishing Group — the title most favoured by US authors in our sample — does not have easily identifiable metrics that distinguish it from non-predatory journals. We contacted the editor-in-chief of the journal, who replied that he hadn't heard of predatory journals but that the journal sends manuscripts to peer reviewers and has rejected manuscripts on the basis of their merit. (Note that at least two other questionable journals carry the same title.)

Our experience with these journals is that they provide both poor vetting and poor access. Their websites and archiving systems are unstable. Although some articles appear in PubMed (often after a delay), the titles are not indexed by Medline and are difficult to find. Indeed, some titles in our sample, such as the *International Journal of Pharmaceutical and Medical Research,* ask authors to assign copyright to the journal, which is against the mores of open access.

Even without Beall's list, savvy authors should know when to suspect that a journal is predatory. Our research group has identified 13 characteristics of predatory journals; these include low article-processing fees (less than US$150); spelling and grammar errors on the website; an overly broad scope; language that targets authors rather than readers; promises of rapid publication; and a lack of information about retraction policies, manuscript handling or digital preservation. Manuscript submissions by e-mail and the inclusion of distorted images are also common[4].

However, predatory journals are becoming increasingly adept at appearing legitimate, and little is being done to warn authors away from them. Just one of the ten most common funders reported in our study, the University Grants Commission, India, provides guidance about journal selection on its website.

STOP THE ROT

We believe that publishers, research institutions and funders should issue explicit warnings against illegitimate publishers and develop cohesive recommendations on publication integrity together.

Funders and research institutions should increase the funds that they make available towards open-access publication; prohibit the use of funds to support predatory journal publications; make sure that researchers are trained in how to select appropriate journals when submitting their work; and audit where grantees, faculty members and research staff publish. When seeking promotion or funding, researchers should include a declaration that their CV is free of predatory publications. Publication lists could be checked against lists such as the Directory of Open Access Journals (DOAJ) or the *Journal Citation Reports*. Developing automated tools to facilitate the proposed audits would also be valuable.

Before approving a study, ethics committees should ask researchers to declare in writing their willingness to work with their institutional resources, such as librarians, to ensure they do not submit to any journals without reviewing evidence-based criteria for avoiding these titles.

If not, predatory journals will continue to erode the integrity of scientific scholarship. Substandard publications have permeated authentic electronic databases. A problem largely unknown a decade ago, there are now a roughly estimated 8,000 predatory titles that collectively 'publish' more than 400,000 items a year[3]. We need to cut off the supply of manuscripts to these illegitimate outfits. ■

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1. Bohannon, J. *Science* **342,** 60–65 (2013).
2. Xia, J. *et al. J. Assoc. Infor. Sci. Tech.* **66,** 1406–1417 (2015).
3. Shen, C. & Björk, B.-C. *BMC Med.* **13,** 230 (2015).
4. Shamseer, L. *et al. BMC Med.* **15,** 28 (2017).
5. van de Wetering, F. T., Scholten, R. J. P. M., Haring, T. & Hooft, L. *PLoS ONE* **7,** e49599 (2012).
6. Page, M. J. *et al. PLOS Med.* **13,** e1002028 (2016).
7. Baker, D., Lidster, K., Sottomayor, A. & Amor, S. *PLoS Biol.* **12,** e1001756 (2014).
8. Taljaard, M. *et al. Br. Med. J.* **342,** d2496 (2011).
9. Machacek, V. & Srholec, M. *Predatory journals in Scopus* (IDEA, 2017); available at http://go.nature.com/2wd3es7

Supplementary information and a full list of authors accompanies this article online: see go.nature.com/2vlnvmw

Appendix 4: Copyright permission

Stop this waste of people, animals and money

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Author Request

Chapter 5: Potential predatory waste

The publication of biomedical research in entities that appear to be credible scholarly journals but which have instead been condemned as "predatory" (1), "deceptive" (2), and "illegitimate"(3) journals, is a problem. In Chapter 4 we demonstrated that what was once thought to be a publishing phenomenon originating in, and largely limited to, lower income countries (4–6) is, in fact, a global problem (7). While the largest proportion of corresponding or last authors of biomedical research in predatory journals are from India (n=511, 27%), the second largest contributing country was the US (n=288, 15%). More than half of articles in the sample named corresponding or last authors from high income or upper-middle income countries overall (n=1067, 57%). While many previous reports have characterised the problem as affecting mainly lower income countries such as India and certain African countries, the research in Chapter 4 shows that this is not the case for biomedical research published in predatory journals. In fact, our findings show that the distribution of predatory publishing is in line with that of legitimate publishing – 59% of scientific research published in legitimate journals originated from corresponding authors in higher income countries in 2016 (8). It is clear that predatory journals are a publishing outlet for researchers worldwide, including those from 'top tier' institutions such as Harvard University (among the top ten most frequent author-affiliated institutions in Chapter 4). The remainder of this chapter focuses on the contribution of predatory journals to avoidable waste in research (9) and the role research funders may play in preventing such waste.

Predatory waste

It has been established that predatory journals publish untrustworthy (i.e., fabricated, falsified, plagiarized, and otherwise questionable) studies (4,10,11). Such research should not contribute to the scholarly record. However, it appears that predatory journals do not only publish such content. In Chapter 4, we found what looks to be legitimate biomedical studies published in predatory journals. The problem with this is that predatory journals and the articles they publish are largely not indexed in bibliographic and citation databases used by researchers (12–14); their content may enter such databases through means other than indexing (15) (see Chapter 7 for further discussion on this). Further, many have called for content from predatory journals to purposely be kept out of the scholarly record so as to avoid 'contamination' (13,16–18). By default, this positions research in legitimate journals as otherwise 'pristine'. The presumed trustworthiness of legitimate journals and their content is further discussed in Chapter 7. At issue here is that some trustworthy science is potentially contained in predatory journals. If such research cannot be easily discovered using typical search strategies and databases used by researchers, including those preparing evidence syntheses, the scientific community may be unaware that it exists. As a result, trustworthy research published in predatory journals may never contribute to future scientific research and evidence-based decision-making. The low and

unreliable discoverability of predatory journals is wasteful for at least three reasons, outlined below:

1. Wastes research contributions and effort

Chapter 4 shows that data obtained from studying millions of patients and thousands of animals are reported on in articles published in predatory journals. Based on our findings, we estimated that if 70% of biomedical journals appearing on Beall's list in 2016 published at least 19 articles over their entire existence1, data from almost 37 million humans and animals may be contained in predatory journals (Chapter 4, Calculation S1). If predatory journals cannot be consistently located, the real human and animal contributions they hold are wasted because they have no ability to benefit future science. This is an unethical outcome for patients who contributed to research and for animals which were used/sacrificed in research with the intention of it benefitting others (19). Additional waste arises from the fact that well-intentioned researchers may be putting time and effort into planning, carrying out, and writing up research that they then send to a journal unaware that it is predatory or unlikely to be found by others. Researchers who publish in journals that do not facilitate dissemination through the channels that other researchers look to for information are also wasting their time producing research (of any quality) that may never be read, or, importantly to some, cited.

2. Slows progress and impedes research diversity

When biomedical research is not discoverable through conventional approaches, this hampers the efficiency and impact of the research process (20–22). Similar to research that cannot be accessed due to paywalls, research that cannot be identified through traditional search mechanisms and sources, is wasted (23). When potentially valid work exists but is not available to be verified and replicated (potentially increasing or decreasing confidence in its findings, it fails to inform future research agendas), redundant research questions may be asked and acted on unnecessarily.

A natural experiment on the impact of openness of research materials occurred in the 1990's when then National Institutes of Health (NIH) director Harold Varmus negotiated open access to two patented mouse models for NIH researchers (while many others remained inaccessible/unmodifiable through patents) (24). While research materials (such as genetically engineered mice) are not a surrogate for research publications, access to either can similarly affect future research. The experiment demonstrated significant associations between the accessibility of research materials and the amount and diversity of research paths (i.e., previously unexplored questions/applications to subspecialties) and contributors (i.e., new researchers) of follow-on research. Research using the open models saw significantly more citations over time, received more citations from new authors who had never previously published in the area, and were published in a more diverse array of journals, compared to research using non-open models. This experiment, reinforced by

[1] In Chapter 2, we found that 30% of biomedical journals from Beall's List had no published content; those that did published a median of 19 articles

subsequent studies on data sharing (25,26), demonstrates the limited reach, uptake, and breadth of impact of follow-on research when research materials are inaccessible. A parallel scenario is likely for research that indiscoverable.

3. Prevents research typically omitted from legitimate journals from being found

It is estimated that approximately half of clinical trials may be unpublished (27–29) and these tend to have results that are statistically non-significant (i.e., 'null') or unfavourable (30,31). This systematic non-publication of some studies (resulting from behaviours of both authors and journals) in legitimate scientific journals on the basis of direction and significance of effect has been termed "publication bias" (32). Data across 30 studies pertaining to 2592 unpublished studies indicates that the top reasons authors do not submit completed research for publication are due to their perceptions about the research/findings (i.e., unimportant or negative results, low priority/have no time, likely to be rejected from a journal) (33). Other prominent reasons include that unpublished studies were not meant for publication, indicating a purposeful withholding of some research from the scientific literature, such as industry-sponsored research (34).

In addition to particular studies or effects being withheld from or left off of the scientific record (i.e., published in legitimate journals) entire groups of researchers as well as certain disease conditions and therapeutics are also systematically missing from the scientific record. This "periphery" of research includes non-English speaking researchers, those from low income countries, diseases affecting those in low-income countries, early career researchers/trainees, and in some instances, women (35–38).

The proportions of research that are unpublished due to non-submission to versus due to rejection from legitimate journals are unclear (and largely inestimable due to closed, journal-based, manuscript decision data). However, the 4% annual increase in the number of articles being published by legitimate journals between 2008 and 2018 (39), shows no disruption of the steady growth trajectory of legitimate journals as a result of predatory journals (which seemed to rapidly increase in number in the second half of that period (40)). As such, one can infer that researchers may be sending research for publication in predatory journals that may otherwise never be published in legitimate journals, possibly due to their negative perceptions about their research or fear of/actual rejection from legitimate journals.

Motivations for publishing in predatory journals

Most authors who responded to two separate 2018 surveys about publishing in a predatory journal (on Beall's List) indicated not knowing about the publishing journals' predatory designation at the time of submission (41,42). This suggests that many researchers who publish in predatory journals are unintentionally doing so. However, these surveys do not account for aforementioned "conscious conspirators". The motivations of such researchers have not been well characterised possibly because such

researchers may be reluctant to incriminate themselves. However, it is possible, and has been documented to some extent (43), that some researchers may be purposely publishing in predatory journals out of frustration with legitimate journal/publishing system (i.e., high rejection rate, editorial processes take too long (33,44)) or perceived pressure to publish for career advancement. Whether researchers are victims or "conscious conspirators" of predatory journals, waste is accruing due to research in predatory journals being undetectable.

In one of the above mentioned surveys, responding authors (206/1165, 18%) indicated that open access (74/206, 35.9%), solicitation (52/206, 25.2%), and affordability (31/206, 15.0%) led them to select the predatory journal about which they were questioned (41). In the other survey, most responding authors (53/79, 67%) indicated applying their typical journal selection process, included a judgment on the perceived quality of the journal and its fit for the research at hand (42). Speed and ease of publication, as well as the inability to get published were listed as the next most influential factors in authors' decision-making process. A 2012 survey of researchers who had recently published in an open access journal, found that journal suitability, quality, and speed of publication were the most important considerations in deciding where to submit research (45). The accessibility of the journal was a significant but less important factor. Since the latter survey predates widespread awareness (4) and growth of predatory journals (46), it likely reflects researchers' decision-making around publishing in legitimate open access journals.

Based on the above findings, it is apparent that journal-related factors (rather than those pertaining to the research, academic/career, or other) are the most direct considerations in researchers' decisions about where to publish. However, it is unclear what researchers understand of journal processes or what information they are basing journal choices on. Such information and guidance are not typically covered in formal research training or professional development (47). It is also unclear whether those who oversee researchers, such as research funders, many of whom have policies about the accessibility of funded research, provide guidance on where to publish or what minimum features a publishing outlet should possess in order to publish funded research.

The role of funders

Those who financially support researchers and research published in predatory journals ought to be concerned about the waste accruing as a result of predatory publishing. Indeed, research grants and national funding agencies are the largest source of funds used to pay for article processing charges (APCs) in biomedicine, supporting publication of at least 50% of open access articles (45). In Chapter 4 we found that 17% of studies in our sample (323/1907) listed some form of funding support. Applying this finding to the entire potential cohort of biomedical journals in existence in 2017, in Chapter 4 (Calculation S2), we estimated that health research funders may have supported publication of up to 18,673 studies in predatory journals. Using a median predatory journal APC of $100 USD (from

Chapter 2), this amounts to a potential $2.7M USD in APCs that may have been paid to predatory journals in 2017. A forthcoming study estimates that NIH-funded researchers may have paid over $3M USD towards a single predatory publisher, OMICS Publishing group (48). This estimate is based on 1,891 OMICS journal articles listed in PubMed Central – a repository primarily for NIH-funded research (48).

In addition to supporting APCs, funders ought to be concerned that their research investments overall may be supporting research that is not identifiable or found. The NIH was the most frequently named funder in articles reporting a funder name in Chapter 4 (13%), followed by two of the largest health research funders in India (49) - the University Grants Commission (5%) and the Indian Council of Medical Research (2.5%). The NIH is the world's largest health research funder, having distributed $27,112,000,000 in research funding in 2018 (50).

Looking to research done about NIH-supported projects, we can gain insight into the hypothetical amount of total research investment (not just APCs) that may be lost to predatory publishing. A median of $240,000 USD in NIH funds2 is estimated to be spent on research contained within a single article that is retracted due to falsification and fabrication (51). Using articles retracted from legitimate journals as a proxy for articles published in predatory journal (since both report research that does not contribute to science), a staggering $500M USD may have been wasted by the NIH supporting research (not just APCs) published in predatory journals in 2017 (i.e., $240,000 USD x 13% [or 2427] of an estimated 18,673 funded biomedical research articles published in predatory journals 2017). This is a top-end estimate since it attributes equal cost to research published in legitimate and predatory journals. However, this is a fair assumption in the absence of evidence of how quality, authenticity, or trustworthiness of research compares between legitimate journals and predatory journals. Particularly, we have no idea how such if done by the same author.

One way that funding agencies have worked to ensure maximum impact and uptake of the research they support is through open access policies. At least 139 research funders worldwide (total number of worldwide funders of health research is unknown) were self-registered as having open access requirements or mandates in the Registry of Open Access Repository Mandates and Policies (ROARMAP, http://roarmap.eprints.org/) at the time of writing. Ideally, such policies should work to prevent research from being published in journals that do not meet the definition of open access (i.e., free access and fair use/re-use copyright (52)) and, more basically, in journals that cannot be reliably be found, such as predatory journals. When research is easily identifiable it can reduce unintentional redundancies in research efforts and investments.

Small and large health research funders are supporting research being published in predatory journals, which are not traditionally identifiable. If health research funders are

[2] average amount attributed to each PubMed listed article supported by the same NIH grant(s) as a retracted article, across 149 grants awarded between 1992 and 2012.

concerned with the return on their investment, they, more than anyone, have the leverage to act to rectify this situation. This could start with, at the very least, explaining their expectations of journals in which researchers publish research that they fund, particularly in terms of discoverability, permanent, and accessibility of that research. Whether funders, or their policies, include such information, is currently unknown. In Chapter 6, we examine this.

References

1. Beall J. Predatory publishers are corrupting open access. Nature. 2012;489:179.

2. FTC Halts the Deceptive Practices of Academic Journal Publishers | Federal Trade Commission [Internet]. 2017 [cited 2017 Dec 20]. Available from: https://www.ftc.gov/news-events/press-releases/2017/11/ftc-halts-deceptive-practices-academic-journal-publishers

3. Moher D, Moher E. Stop Predatory Publishers Now: Act Collaboratively. Ann Intern Med. 2016 May 3;164(9):616.

4. Bohannon J. Who's afraid of peer review. Science. 2013;342:60–5.

5. Seethapathy GS, Santhosh Kumar JU, Hareesha AS. India's scientific publication in predatory journals: need for regulating quality of Indian science and education. Curr Sci. 2016;111(11):1759–64.

6. Pulla P. Predatory publishers gain foothold in Indian academia's upper echelon. Science (80-). 2016 Dec 16;

7. Moher D, Shamseer L, Cobey KD, Lalu MM, Galipeau J, Avey MT, et al. Stop this waste of people, animals and money. Nature. 2017 Sep 7;549(7670):23–5.

8. Board NS. Science and Engineering Indicators. Alexandria, VA; 2018.

9. Macleod MR, Michie S, Roberts I, Dirnagl U, Chalmers I, Ioannidis JPA, et al. Biomedical research: increasing value, reducing waste. Lancet. 2014 Jan 11;383(9912):101–4.

10. Deprez EE, Chen C. Medical Journals Have a Fake News Problem. Bloomberg Businessweek. 2017 Aug;

11. Owens JK, Nicoll LH. Plagiarism in Predatory Publications: A Comparative Study of Three Nursing Journals. J Nurs Scholarsh. 2019 May 5;51(3):356–63.

12. Crawford W. Gray OA 2012-2016: Open access journals beyond DOAJ. Cites & Insights. 2017;17(1).

13. Macháček V, Srholec M. Predatory journals in Scopus. 2017.

14. Manca A, Moher D, Cugusi L, Dvir Z, Deriu F. How predatory journals leak into PubMed. CMAJ. 2018 Sep 4;190(35):E1042–5.

15. Topper L. RE: How predatory journals leak into PubMed [Internet]. CMAJ. 2018 [cited 2020 Jan 8]. Available from: https://www.cmaj.ca/content/re-how-predatory-journals-leak-pubmed

16. Beall J. Ban predators from the scientific record. Nature. 2016 Jun

15;534(7607):326–326.

17. Manca A, Cugusi L, Dvir Z, Deriu F, Dvir Z, Deriu F. PubMed should raise the bar for journal inclusion. Lancet (London, England). 2017 Aug 19;390(10096):734–5.

18. Ferris LE, Winker MA. Ethical issues in publishing in predatory journals. Biochem Medica. 2017 Jun 15;27(2):279–84.

19. Groves T. Enhancing the quality and transparency of health research. BMJ. 2008 Jul 8;337(jul08 1):a718–a718.

20. DOAJ to remove approximately 3300 journals | News Service on WordPress.com [Internet]. [cited 2016 May 13]. Available from: https://doajournals.wordpress.com/2016/05/09/doaj-to-remove-approximately-3300-journals/

21. Cornell A, Bushman B, Womack K. Analysis of journals that did not meet selection criteria for inclusion in the national library of medicine collection but have manuscripts in pubmed central. J Med Libr Assoc. 2011 Apr;99(2):168–70.

22. Topper L, Boehr D. Publishing trends of journals with manuscripts in pubmed central: Changes from 2008–2009 to 2015–2016. J Med Libr Assoc. 2018 Oct 1;106(4):445–54.

23. Chan A-W, Song F, Vickers A, Jefferson T, Dickersin K, Gøtzsche PC, et al. Increasing value and reducing waste: addressing inaccessible research. Lancet. 2014 Jan;383(9913):257–66.

24. Murray F, Aghion P, Dewatripont M, Kolev J, Stern S. Of Mice and Academics: Examining the Effect of Openness on Innovation. Am Econ J Econ Policy. 2016 Feb;8(1):212–52.

25. Piwowar HA, Day RS, Fridsma DB. Sharing Detailed Research Data Is Associated with Increased Citation Rate. Ioannidis J, editor. PLoS One. 2007 Mar 21;2(3):e308.

26. Christensen G, Dafoe A, Miguel E, Moore DA, Rose AK. A study of the impact of data sharing on article citations using journal policies as a natural experiment. Naudet F, editor. PLoS One. 2019 Dec 18;14(12):e0225883.

27. Song F, Parekh, S, Hooper L, Loke YK, Ryder J, Sutton AJ, et al. Dissemination and publication of research findings: an updated review of related biases. Vol. 14, Health technology assessment (Winchester, England). Prepress Projects Limited; 2010. iii, ix–xi, 1–193.

28. Schmucker C, Schell LK, Portalupi S, Oeller P, Cabrera L, Bassler D, et al. Extent of Non-Publication in Cohorts of Studies Approved by Research Ethics Committees or Included in Trial Registries. Petersen I, editor. PLoS One. 2014 Dec 23;9(12):e114023.

29. Powell-Smith A, Goldacre B. The TrialsTracker: Automated ongoing monitoring of failure to share clinical trial results by all major companies and research institutions. F1000Research. 2016 Nov 3;5:2629.

30. Dwan K, Gamble C, Williamson PR, Kirkham JJ. Systematic Review of the Empirical Evidence of Study Publication Bias and Outcome Reporting Bias — An Updated Review. PLoS One. 2013;8(7):e66844.

31. Golder S, Loke YK, Wright K, Norman G. Reporting of Adverse Events in Published and Unpublished Studies of Health Care Interventions: A Systematic Review. Ioannidis JP, editor. PLOS Med. 2016 Sep 20;13(9):e1002127.

32. Dickersin K, Chan S, Chalmers TC, Sacks HS, Smith H. Publication bias and clinical trials. Control Clin Trials. 1987 Dec;8(4):343–53.

33. Song F, Loke Y, Hooper L. Why Are Medical and Health-Related Studies Not Being Published? A Systematic Review of Reasons Given by Investigators. Wicherts JM, editor. PLoS One. 2014 Oct 15;9(10):e110418.

34. Doshi P, Dickersin K, Healy D, Vedula SS, Jefferson T. Restoring invisible and abandoned trials: a call for people to publish the findings. BMJ. 2013 Jun 13;346(jun13 2):f2865–f2865.

35. Bryant K. Research from the global south: the important role of context in international research activities. McGill J Educ / Rev des Sci l'éducation McGill. 2014;49(1).

36. Xia J, Harmon JL, Connolly KG, Donnelly RM, Anderson MR, Howard HA. Who publishes in "predatory" journals? J Assoc Inf Sci Technol. 2015 Jul;66(7):1406–17.

37. Mueller CM, Gaudilliere DK, Kin C, Menorca R, Girod S. Gender disparities in scholarly productivity of US academic surgeons. J Surg Res. 2016 Jun 1;203(1):28–33.

38. Bendels MHK, Müller R, Brueggmann D, Groneberg DA. Gender disparities in high-quality research revealed by Nature Index journals. Lozano S, editor. PLoS One. 2018 Jan 2;13(1):e0189136.

39. National Science Board NSF. Publication Output: U.S. Trends and International Comparisons. Science and Engineering Indicators 2020. Alexandria, VA; 2020.

40. Beall J. Beall's List of Predatory Publishers 2017 [Internet]. Scholarly Open Access. 2017. Available from: http://web.archive.org/web/20170103170903/https://scholarlyoa.com/

41. Cohen AJ, Patino G, Kamal P, Ndoye M, Tresh A, Mena J, et al. Perspectives From Authors and Editors in the Biomedical Disciplines on Predatory Journals: Survey Study. J Med Internet Res. 2019 Aug 30;21(8):e13769.

42. Cobey KD, Grudniewicz A, Lalu MM, Rice DB, Raffoul H, Moher D. Knowledge and motivations of researchers publishing in presumed predatory journals: a survey. BMJ Open. 2019 Mar 23;9(3):e026516.

43. Hern A, Duncan P. Predatory publishers: the journals that churn out fake science. The Guardian. 2018;

44. Powell K. Does it take too long to publish research? Nature. 2016 Feb;530(7589):148–51.

45. Solomon DJ, Björk B-C. Publication fees in open access publishing: Sources of funding and factors influencing choice of journal. J Am Soc Inf Sci Technol. 2012 Jan;63(1):98–107.

46. Beall J. Scholarly Open Access [Internet]. 2017 [cited 2017 Jan 1]. Available from: http://web.archive.org/web/20170103170903/https://scholarlyoa.com/

47. Wager E. Why we should worry less about predatory publishers and more about the quality of research and training at our academic institutions. Vol. 27, Journal of Epidemiology. Japan Epidemiology Association; 2017. p. 87–8.

48. Manca A. Personal Communication. 2020.

49. Dandona L, Dandona R, Kumar Ga, Cowling K, Titus P, Katoch V, et al. Mapping of health research funding in India. Natl Med J India. 2017 Nov 1;30(6):309.

50. Samberg R, Schneider RA, Taylor A, Wolfe M. It's time for the US to get serious about funding open access [Internet]. Nature Index. 2018 [cited 2019 Oct 21]. Available from: https://www.natureindex.com/news-blog/its-time-for-the-us-to-get-serious-about-funding-open-access

51. Stern AM, Casadevall A, Steen RG, Fang FC. Financial costs and personal consequences of research misconduct resulting in retracted publications. Elife. 2014;3:e02956.

52. Bethesda Statement on Open Access Publishing [Internet]. [cited 2016 Mar 31]. Available from: http://legacy.earlham.edu/~peters/fos/bethesda.htm

Chapter 6: Top health research funders' guidance on selecting journals for funded research

Note: The text in this has been reproduced from the published article found in Appendix 4.

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Abbreviations	AAAS: American Association for the Advancement of Science BMBF: Bundesministerium für Bildung und Forschung/Federal Ministry of Education and Research (Germany) CCCV: Canadian Common CV CIHR: Canadian Institutes of Health Research EU: European Commission IDRC: International Development Research Council (Canada) INSERM: Institut National de la Santé Et de la Recherche Médicale ISSN (International Standard Serial Number) NIH: National Institutes of Health NLM: National Library of Medicine ODA: Official Development Assistance PMC: PubMed Central PPP: Public-Private Partnerships RPRR: Research Performance Progress Report SHERPA: Securing a Hybrid Environment for Research Preservation and Access US: United States USD: United States Dollar UK: United Kingdom
Appendices	Appendix 1: Author Contributions Appendix 2: Published Article Appendix 3: Copyright

Top health research funders' guidance on selecting journals for funded research

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Abstract

Background: Funded health research is being published in journals that many regard as "predatory", deceptive, and non-credible. We do not currently know whether funders provide guidance on how to select a journal in which to publish funded health research.

Methods: We identified the largest 46 philanthropic, public, development assistance, public-private partnership, and multilateral funders of health research by expenditure, globally as well as four public funders from lower-middle income countries, from the list at https://healthresearchfunders.org. One of us identified guidance on disseminating funded research from each funders' website (August/September 2017), then extracted information about selecting journals, which was verified by another assessor. Discrepancies were resolved by discussion. Results were summarized descriptively. This research used publicly available information; we did not seek verification with funding bodies.

Results: The majority (44/50) of sampled funders indicated funding health research. 38 (of 44, 86%) had publicly available information about disseminating funded research, typically called "policies" (29, 76%). Of these 38, 36 (95%) mentioned journal publication for dissemination of which 13 (36.11%) offer variable guidance on selecting a journal, all of which relate to the funder's open access mandate. Six funders (17%) outlined publisher requirements or features by which to select a journal. One funder linked to a document providing features of journals to look for (e.g. listed in the Directory of Open Access Journals) and to be wary of (e.g., no journal scope statement, uses direct and unsolicited marketing).

Conclusions: Few funders provided guidance on how to select a journal in which to publish funded research. Funders have a duty to ensure that the research they fund is discoverable by others. This research is a benchmark for funder guidance on journal selection prior to the January 2021 implementation of Plan S (a global, funder-led initiative to ensure immediate, open access to funded, published research).

Background

A 2017 investigation found that a considerable number of biomedical research studies supported by well-known funding organizations such as the National Institutes of Health (NIH), were published in so-called "predatory journals" (1). Predatory journals are regarded as non-credible and are criticized for failing to provide typical or expected publishing services and their lack of transparent operations (2,3). Such services include peer review, long term preservation of content, and indexing in scientific, bibliographic databases. Among predatory journals' many shortcomings, the failure to ensure permanent, future discoverability of research is a prominent feature threatening the integrity of science. Research that cannot be found by others cannot contribute to science, thus time, money, and resources are wasted (1,4). Funders ought to be concerned that funded research may be published in journals that do not ensure discoverability of content ensuring it is available to contribute to future science. Benefits from investments in research are difficult to quantify (5). One of the few ways for research funders to measure returns on investments is by tracking research outputs, including scholarly publications (6). Predatory journals may limit the scientific return of funders' investments if their content cannot be reliably found.

Funders & Open Access

Most major funders of health research now mandate that funded research outputs be open access (7). Such open access mandates typically require researchers to ensure that research (and sometimes data) is published in an open access journal or is deposited in a publicly accessible digital repository (regardless of whether the publication was published in an open access journal), or both. Some journals, called delayed-access journals, may impose an embargo period only after which an article is made publicly available or can be archived in a repository. Many funders' policies allow for such delays in open access to accommodate publishers' preferences.

Open access policies are one way for funders to direct funded researchers towards publishing in credible journals abiding by established open access tenets (8):

Research is/should be freely available and accessible to anyone.

The copyright accompanying published work should be open, allowing for free use and re-use (i.e., allowing research to be freely built on/adapted with attribution).

To facilitate researcher adherence with funder open access policies, many biomedical journals offering open access have agreements with the PubMed Central (PMC) repository to automatically deposit their published content on authors' behalf (9). Additionally, researchers funded by the NIH and 13 partner funding organizations in the USA can upload funder-supported publications to PMC from journals without PMC agreements (10). Likewise, 29 funders from across Europe can submit funder-supported research to Europe PMC (which is mirrored in PMC) (11). For some of these organizations, such as the NIH and Wellcome Trust, archiving in PMC or Europe PMC, respectively, is mandatory.

Predatory journals often market themselves as 'open access' and work to aggressively attract submissions (12,13). Research in predatory journals may indeed be free to access – if it can be discovered. However, at best, predatory journals' identification through search engines is sparse and inconsistent, and these journals tend not to be indexed in scientifically-curated, bibliographic databases used by researchers (14–16). Rather, predatory journal articles may appear haphazardly in search engines such as PubMed (since it includes author-uploaded articles from PMC) (17). Additionally, we do not know whether content in predatory journals will be perpetually available if a journal ceases to operate. Content preservation is typically secured by publishers through service agreements with digital preservation providers (e.g. Lots of Copies Keep Stuff Safe, LOCKSS). For journals indexed in Medline, for example, this is a prerequisite of indexing (18); PMC functions as a preservation service (i.e., has a remit to preserve content funded by public money) (19). It is unknown whether predatory journals, not formally indexed in Medline, PMC, or other databases with similar requirements, have digital preservation arrangements.

Most researchers have a limited understanding of what open access means beyond making research free to read (20–23). Free use and unrestricted re-use of research is a fundamental component of open access and licensing to permit this is a regular component of open access journals (24). Journals running nefarious and deceptive publishing operations have likely benefited from or exploited this lack of awareness (25). Indeed, few predatory journals mention licensing for articles or provide information on the use and re-use of published research (24). Without explicit licensing for published articles, the legalities around distributing or building on research in predatory journals, for example, is uncertain. Whether researchers are deceived by predatory journals or are knowingly seeking easy and rapid publications in them (these journals tend to deliver quicker turnaround time than credible journals due to subpar or non-existent peer review (26,27)), they are likely breaching the open access policies set out by their funders.

In January 2017, the Bill & Melinda Gates Foundation implemented a policy mandating open access to research publications and data, without delay for all funded research (28). In February 2017, they initiated a one-year partnership pilot with the American Association for the Advancement of Science (AAAS) to enable Gates-funded research to be published as open access in five AAAS journals, including *Science* (29). The Gates-AAAS partnership seemed to inspire several other influential journals (i.e., New England Journal of Medicine, Proceedings of the National Academy of Sciences) to introduce policies ensuring permanent open access for Gates-funded research (30).

In January 2021, a number of international funders (including UK Research and Innovation, the Gates Foundation, Wellcome Trust, and the World Health Organization), led by Science Europe (a group representing funders across Europe), are set to deliver a radical change to the way that funded research is published via Plan S (coalition-s.org). Plan S will, in part, require research funders to mandate open access to funded research through publication in an open access journal or on an open access platform; and require that publications be made available through an open access repository immediately upon publication. To support this, agreed funders will

pay the cost of article processing charges (APCs) (up to a yet unannounced limit) to journals that are immediately and wholly open access (sometimes referred to as 'gold' open access).

Whether health research funding bodies, prior to Plan S, provide funded researchers with guidance or support towards selecting publishing journals in line with their policies and which facilitate proper access to research, and whether they monitor such policies, is unknown. Previous studies confirm that many non-commercial health research funders' have policies requiring open access to completed research or results via publication or otherwise (31,32). Yet none seem to have assessed whether funders provide any specific information to researchers to facilitate their choice of publishing journal. For public or charitable funders, providing such guidance or support may be one way of ensuring responsible stewardship of public or donor funds. The current work will establish a pre-Plan S baseline of health research funders' guidance and recommendations to researchers for selecting journals in which to publish funded research.

The aim of this research was to describe the policies and recommendations of major health research funding bodies regarding suitable publication venues for funded research.

Methods

We considered the public websites of 50 health funding bodies for statements, guidance, or policies specifically mentioning the publication of funded research. Detailed methods and rationale for this study are elaborated in an *a priori* study protocol (https://doi.org/10.17605/OSF.IO/J6CSK) and summarized below.

Data source

Global funding bodies with the largest documented health research expenditures were sampled from the curated Health Research Funder's list found at: www.healthresearchfunders.org (33). The list was developed as part of an unfunded post-doctoral project by researchers in the Netherlands (33). It was last updated in 2016; expenditure data are reported in 2013 US dollars (USD, accounting for inflation/deflation rates by country). A detailed account of the systematic process used to identify funders and obtain expenditure data is found here: http://www.healthresearchfunders.org/faq/. At the time of retrieval for this study (August 2017), 287 health research funding bodies from 30 countries were included on the list. The list distinguishes five categories of funders: [1] philanthropic funders (n=194), [2] public funders (n=77), [3] public funders who fund health research through Official Development Assistance (public ODA)[1] (n=8), [4] multilateral funders (funding across countries) (n=7), and [5] public-private partnerships (PPP) (n=1) (Table 1). While there are some inequities in its coverage (e.g. public funders were selected from only G20 countries;

[1] ODA is a term coined by the Development Assistance Committee of the Organisation for Economic Co-operation and Development (https://data.oecd.org/oda/net-oda.htm)

paucity of funders from low income countries), the list is likely the most comprehensive source of global health research funder expenditure information in existence (personal communication, Dr. Beverley Holmes, Michael Smith Foundation for Health Research) and has been used to construct samples in at least two other studies (32,34). This study excludes commercial funders since their expenditure data are not publicly or readily available.

Sampling

To construct our sample, we sought up to 15 funders with the largest expenditures from each of the five funder categories from the list at www.healthresearchfunders.org, and aimed to include all listed lower income countries (n=4) if they were not otherwise represented in the sample. We included the latter group of funders in order to ensure representation from lower income countries, since researchers and journals from these countries have been disproportionately implicated in predatory publishing (24,35). Working with the available number of funders in each category (Table 1), we ended up with 50 funders: 15 philanthropic, 15 public, eight public ODA, seven multilateral, one PPP, and four lower-middle income country funders.

In line with previous investigations into health research funder policies (32,36), we expected that guidance for funded researchers would be publicly available and easily obtained. For each included funder, one of us (LS) visited the website using the URL provided by www.healthresearchfunders.org, or if the URL was not working, found it through a Google search using the funder name. When a funder's website could not be located/did not work or when the funder was a duplicate, the next largest funder on the list was used. For each funder, we sought and downloaded the website section on policies for funded research in August-September 2017. If no specific policies were found, we searched the SHERPA (Securing a Hybrid Environment for Research Preservation and Access)/Juliet database (www.sherpa.ac.uk/juliet/index.php), which lists and links conditions for open access publication for some funders (though this is incomplete as it is reliant on voluntary contributions from funders and other organizations [e.g., libraries] tracking funder policies). If a funder's website did not mention funding health research (i.e., funded other scientific research) or if the funder did not specifically award grants for research, the funding body was excluded from the sample and replaced with the next largest funder (by expenditure), where possible. Reasons for exclusion are documented in Figure 1.

Data extraction

One assessor (LS) extracted information from the downloaded policy documents into an online form in Distiller SR, and a second assessor (KDC or MJP) verified the extracted data. Discrepancies were resolved by discussion. If additional documents were identified during extraction, we saved them and searched them for the desired data. The verification process

led to clarifications in collected data or provided additional information. The following information was assessed or extracted, as available:

- Any statement(s) about the dissemination of outputs from funded research
- Policy or recommendations about publication of funded research
- Policies or recommendations on research/data accessibility
- Policies or recommendations on journal quality, impact factor or other metric, ethical standards, and indexing of funded research;
- Whether/what information is provided to researchers about predatory or substandard journals, or about journal credibility
- Strength of any aforementioned policies/recommendations ('must', 'should', or 'suggested')
- For publication policies, whether adherence will be monitored
- For publication policies, whether consequences of non-adherence are listed

If non-English websites or documents were encountered and an English-language version was not available on the website, Google Translate was used to automatically translate the websites and documents. Google Translate has recently shown 85%-97% accuracy across 9 languages for translating health research studies (37), including the languages encountered in this study (French and German).

Data analysis

We summarized data descriptively by calculating proportions for dichotomous data; the date of funder policies/recommendations were summarized as medians and interquartile range.

Protocol deviations

In the protocol for this study, we stated that we wanted to determine whether there were differences in the number of funders with policies/statements about journal quality and predatory publishing based on the income-level of the funder country or country being funded. However, as only four funders from lower-middle income countries and none from low-income countries were on the list we sampled from, there were not enough funders to enable meaningful comparisons between higher income and lower income countries.

Results

For the 50 funding bodies originally identified using the described sampling technique, three allocated money from a funder (European Commission[1]) already in the sample and were replaced with the next organizations on the list. One of the replacement funders also allocated

[1] Any European Commission funding program that explicitly stated using the European Horizon 2020 guidelines for grantees were jointly represented as "European Commission". (Figure 1)

money from an included funder and was also replaced. Two funders funded non-health research and four funders did not list any research grants (and appeared to fund health development initiatives) and could not be evaluated for our purposes. Overall six funders were excluded and lacked replacements in the categories they belonged to. 44 funders remained in the sample for which grant policies and guidelines were sought (Figure 1). 35 funders are from high income countries, one from upper-middle income (China), three are from a lower-middle income country (India), and five are not classified by income level because they are multilateral (n=3) or fund across the European Union (EU) (n=2, Table 2).

38 of 44 funders (86%) had publicly available information for grantees about disseminating funded research outputs (Table 3). Of the six funders that did not have publicly available information, five are from high-income countries (US, Germany, France, UK) and one funds research in the EU through public-private partnership. Three are philanthropic organizations and two are public-ODA funders. Information about disseminating research was contained within "policies" for 29/38 (76%) funders, "recommendations" (suggestions and guidance) for 8/38 (21%) of funders, and as a "code of conduct" for one funder (Table 3). All but one policy/recommendation referred to funded research (including results) as the unit of dissemination (37/38, 97%). Over a third of policies/recommendations also specifically mentioned the dissemination of "data" (25/38, 66%). The median implementation date or date listed on collected documents was September 2014 (IQR: Apr 2012 to Apr 2016, n=35).

Open access and journal selection

36 of 38 policies/recommendations (95%) specifically referred to publication in a journal as one form of dissemination for completed research (Table 4). 31 of these (86%) mentioned that research should be open access, either through journal publication (n=24, 77%) or through self-archiving the final report or accepted manuscript in a freely accessible repository (such as PMC) (n=30, 97%). One funder from India (Indian Council of Medical Research), one from France (Institut National de la Santé Et de la Recherche Médicale, INSERM), and three from the USA (US Department of Defense, Congressionally Directed Medical Research Program, and the American Cancer Society) did not mention open access in their policies about research dissemination.

13 of 36 (36%) policies recommending publication contained some guidance on how to select a journal and six (17%) listed features or requirements of publishers or journals for researchers to look for (Table 5). These six are described here. Only one funder policy (NIH) included a definition of a journal (i.e., either a publication listed in the journal section of the National Library of Medicine or one meeting stated criteria). And only one funder policy (Canadian International Development Research Council, IDRC) appeared to provide any information about 'questionable' journals in a guidance document entitled "Publishing in Open Access Journals". The document lists journal features to "look for" and to "be wary of" and mentions

Beall's List[2] as a resource (Table 5). One policy (Deutsche Forschungsgemeinschaft/German Research Foundation, DFG) linked to Think, Check, Submit (www.thinkchecksubmit.org) – an initiative to facilitate researchers' assessment of the credentials of a journal – on a page supplementing their open access policy listing open access resources. Two funders distributing APC fees through the Charitable Open Access Fund (Cancer Research UK and Wellcome Trust) list the requirements of journals whose APCs are eligible for payment through the fund. The Bill and Melinda Gates Foundation provide researchers with a portal (called Chronos) through which to submit manuscripts directly to pre-selected journals whose standards are in line with their requirements.

The policies of at least three funders (German Federal Ministry of Education and Research Indian [BMBF], Indian Department of Biotechnology [DBT], Indian Department of Science & Technology [DST]) include a statement that further to making research freely accessible, researchers' choice of journal was unrestricted.

Other journal characteristics mentioned by funders

Most funders mentioned that funded research should be peer reviewed or published in a peer reviewed journal (Table 4). Four funders made non-specific reference to selecting a "good" or "quality" journal in relation to publication of funded research; none mentioned the journal impact factor. Eight funders made statements about publication transparency or ethics. For instance, one funder discussed reproducibility in published research, three mentioned adherence to reporting guidelines, and at least six asked that metadata accompany published articles (Table 6).

Adherence to policies/recommendations

Of 38 policies/recommendations providing information about disseminating research outputs, only nine (24%) stated that they monitor adherence to either a policy (n=7) or recommendation (n=2); two philanthropic funders (Wellcome Trust and Bill & Melinda Gates Foundation) specified that they would evaluate publications of funded research reported to them to ensure they are published in journals meeting the funder's outlined publishing requirements (Table 7). No monitoring or adherence data appears to be publicly available. Only five (13%) funders with policies or recommendations about journal publication indicated that there would be consequences for non-adherence. And only two of those (Wellcome Trust and NIH) stated that they would withhold or suspend payments if articles are not made open access.

[2] Beall's List is an archived listing of potential predatory journals and publishers, as determined by librarian Jeffrey Beall between 2011 and 2017, https://web.archive.org/web/20170103170903/https://scholarlyoa.com/

Discussion

Most health research funders appear to have active policies about the dissemination of funded research, typically in the form of policies about open access which often include statements about journal publication. Few policies provide guidance on how to select a journal, list features of journals meeting funder requirements, or about the credibility of publishing outlets. Only one health research funding organization (IDRC) made specific reference to the "questionable journals" at the time of data collection (August-September 2017). Additionally, few policies describe whether funded outputs are monitored for compliance with funders' dissemination policies, and few describe any consequences for researchers' non-adherence to their policies. Information is not available on whether the NIH or Wellcome Trust, both of whom promise to withhold or suspend grant funds for breaching their open access policies, have actually ever done so (7).

For many of the funders in our sample, information to guide publication of research was found across multiple documents and not always within the main open access policy statements/documents. For example, the only funder to provide guidance about predatory journals (IDRC) did so in a PDF (entitled "Publishing in Open Access Journals") that was linked to from their main open access policy. The policy itself did not flag that the document contained information about predatory/questionable/non-credible journals. This non-obvious placement of guidance or expectations around adherence to their funder policies relies on researchers' curiosity or knowledge that important information may be located outside of the main policy webpages or documents. If funders wish to provide guidance about journal credibility and predatory publishing, they may reach more researchers (and increase the likelihood of them reading it) by including such information within a single, main policy document aimed at funded researchers.

Comparison to other research

At least four previous studies examining health research funder policies on clinical trial transparency have collected information on funder's recommendations for disseminating research.

Two studies using similar methods evaluated trial transparency policies (i.e., those related to trial registration, access to summary results, individual data availability) for non-commercial health research funders globally (n=18) (32) and in the USA (n=9) (34). After accounting for three common funders across studies, 21 of 24 (87.5%) funders (16 of which are represented in our study) either required or supported publication or registration of trial results (neither study or their available data distinguished between publication or registration). This is in line with our findings in which 86% (38 of 44) funders had such policies/recommendations.

A third study, published in 2017 which examined research waste-reducing policies of 11 non-commercial funders (six of which are represented in our study) reported six to be explicit in

requiring publication of full reports of funded research (31). In comparison, 36 of 38 policies/recommendations (95%) in our study referred to journal publication as one form of dissemination for completed research but did not indicate that it was mandatory. There may be differences in how authors of that study and interpreted language in documents or policies. The names of the six funders 'requiring' publication in that study were not obvious in either the publication or available data, so we are unable to investigate this further.

A study published in 2008 examined 73 UK and international non-commercial health research funders' guidance for reporting funded clinical trials (38). 49 funders (67%) explicitly stated that trials could or should be published. Of the three funders appearing in the 2008 sample and ours, all have maintained recommending (but not requiring) the publication of trial results. The study did not collect Whether funders provided any guidance on selecting a journal to publish in was not collected in the study.

No previous studies appear to have investigated whether health research funders provide guidance to help funded researchers select a journal for publication. Our study appears to be the most comprehensive investigation on this matter. This is surprising since our findings suggest that funders in our sample regard publication as the primary means of disseminating funded research. Further, studies show that researchers view journal publication as the primary way of disseminating research (39,40).

Strengths and limitations

This study is the first to examine the information funders provide researchers about selecting a journal in which to publish funded research. All funders in our sample that mention journal publication or provide guidance on selecting journals, do so within their open access policies. In a time where the scholarly publishing landscape has been infiltrated and confused by predatory journals, inadvertently resulting in some researchers trying to achieve open access to publish in predatory journals (41), funders can play a critical role in steering researchers in the right direction. Funders can be specific and explicit with regards to which journal features researchers should look for in order to select one that meets their open access requirements.

This study is an essential benchmark by which to monitor how major health research funders are performing pre and post Plan S implementation (planned for January 2021, at the time of writing). Data collection occurred in August & September 2017, prior to the September 2018 announcement of Plan S. So far, 24 funders have committed to implementing Plan S, five of which were considered in this research (European Commission, Gates Foundation, MRC/UK Research and Innovation, Wellcome Trust, and the World Health Organization). Two of these, the Wellcome Trust and Gates Foundation, provided guidance (in the form of tools) to facilitate selecting a journal in line with their open access policies at the time of sampling. At least one funder (Wellcome Trust) has made changes to their open access policies in anticipation of Plan S (42).

Our study relied on publicly available information about funder expectations of funded research and was abstracted by a single person with verification by a second (i.e., not two

independent people). Six funders in our sample did not provide any relevant public information. We did not seek verification on policies from funders since data collection took place at a time when the publishing activities, particularly open access, was (and still is) rapidly changing, somewhat in response to the rise of predatory journals (41,43). We are aware that the NIH issued a notice on their Public Access Policy in November 2017 (outside of our sampling and data collection period) with recommendations to publish funded research in journals with 'credible practices' (44). The focus of this research is limited to health research funders. We have not accounted for or evaluated other potential scientific publishing gatekeepers such as academic institutions, governments, or companies carrying out scholarly research, despite the important role they can play (45).

Implications and recommendations for funders

Explicit funder policies on publication expectations

Selecting a journal in which to publish research is not a straightforward undertaking (46), particularly since the emergence of predatory journals. For funders looking to make their expectations around publishing funded research more explicit and more transparent, we propose several recommendations on how this might be achieved in Box 1, based on findings of this research and on the expertise of authors. Providing specific information about journal considerations in funders' policies to funded researchers may facilitate more thoughtful and responsible selection of journals. Several recommendations in Box 1 pertain to the explicitness of article/journal considerations mentioned in Plan S (e.g., persistent identifiers for publications; long-term preservation/archiving; article-level metadata). All health research funders may wish to consider making aspects of their policies that pertain to publishing more explicit, whether or not they intend to implement Plan S.

The NIH is the only funder in our sample to clearly describe what it considers a journal – either those listed in the journal section of the National Library of Medicine (NLM) (https://www.ncbi.nlm.nih.gov/nlmcatalog/journals) or those meeting a comprehensive set of criteria (47): (1) meets the requirements for ISSN (International Standard Serial Number) assignment; (2) content is issued over time under a common title; (3) is a collection of articles by different authors; and (4) is intended to be published indefinitely. All but the final criterion are straightforward to judge; presumably it is meant to distinguish a journal from a book or a monograph however NIH or NLM do not provide guidance on how to judge this criterion. However, whether journals intend to publish indefinitely can be predicted or otherwise determined has not been described. A more meaningful criterion for distinguishing journals from non-journals may be whether the publishing entity has archival arrangements in place (e.g., with LOCKSS, Portico, PubMed Central) to ensure perpetual access to content in the event a journal ceases to operate. Since preserving publisher content may have associated costs (48), predatory or non-credible journals (which have been described as "primarily fee-collecting operations" (49)) are potentially unlikely to seek this service.

We surprised that the three funders from India in our sample (Indian Council for Medical Research, DBT, and DST) did not mention journal credibility or predatory journals, and further,

that a common policy for two Indian funders (DST and DBT), dated December 2014, recognizes "the right of researchers to publish their work in journals of their choice, because researchers are the best judges of where to publish their work". Since at least 2016, there has been an ongoing national initiative combat predatory journals and to support researchers in their choice of journals across higher education institutes in India. The main product of this work has been a list of approved journals in which academic researchers are permitted to publish in as well as standard templates for researchers when communicating with journals (50). The University Grants Commission (UGC), the regulator and funder of high education, has been leading the initiative. It is uncertain whether the country's largest health research funders are on board due to their lack of guidance in this space. A coordinated approach by a range of stakeholder groups (45), which includes funders (who have innate authority to implement mandates about publishing), may facilitate improved publication decisions by researchers. Importantly, however, UGC's list of approved journals has been plagued with numerous credibility concerns in its short existence (51,52). Explicit recommendations from India's funders regarding credible and non-credible features of journals in which to publish may be warranted in the absence of a trusted and comprehensive list.

Facilitating and monitoring adherence to funder policies

Funders are well-positioned to provide researchers with resources and tools to help ensure that results from funded research are published in credible and discoverable journals, in line with their policies. Several organizations in our sample consistently offer more information about potential publishing routes and tools to facilitate adherence to their policies. We provide a list of tools to facilitate the development of funder policies on research outputs, adherence to such policies, and monitoring of policy adherence (Table 8).

Monitoring researchers' adherence to their policies may help funders understand the extent to which researcher's publishing practices are guided by their policies (53). Informing researchers that their adherence to open access policies is being monitored may facilitate better awareness of such policies and potentially increase adherence to them (54). A 2018 study examining the accessibility of research supported by 12 research funding agencies across North America and Europe with open access policies, found that 62% of almost 1.3 million articles over nine years were freely available (7). In 2016, 90% of published research supported by the NIH and Wellcome Trust was free to access (via journal, repository, or both) (7). Both agencies mandate the deposit of published research by publishing journals or funded authors into dedicated repositories (PMC for NIH; PMC Europe for Wellcome Trust). The remaining 10 funders in the sample did not mandate depositing in a repository alongside publication and had lower rates of freely accessible articles. For example, for the Canadian Institutes of Health Research (CIHR) only 55% of published research was freely accessible in 2016, even though the funder had a dedicated repository (PMC Canada) until 2018 (it closed due to low usage and high upkeep costs) (55). The study's authors conclude that funders with low compliance rates used less enforcement and had less infrastructure to support compliance with their open access mandates (7).

Areas of future research

An important area of future study is whether researchers are being funded on the basis of grant applications that include research published in predatory journals – or in journals that may not be indexed in trusted databases. Predatory journals have made their way into consideration (via CVs submitted by researchers or through institution-initiated database searches) into applications for academic career advancement (56–58). Some have called for such publications to either be discounted from consideration or for researchers who submit them for consideration to be prevented from career advancement overall (59,60). It is unknown whether researchers are including publications in predatory journals as part of their funding applications. This should be evaluated. If they are, funders may wish to consider whether this is an important consideration for awarding funding.

Conclusion

Most large health research funders mandate open access to funded research outputs, typically by way of open access journal publication and by deposition of published research in digital repositories. Few funders provide guidance on what constitutes a journal (or an open access journal) or are checking to ensure that published research that they have funded is indeed meeting specified requirements about how research should be shared. Health research funding organizations have an obligation to support researchers in meeting their mandates so that research can, as intended, contribute to the broader evidence base. The publishing community needs to provide guidance to funders and researchers on universally acceptable and transparent standards for journal operations. Many solutions to improve policies, facilitate adherence, monitor compliance and work with other funders on large-scale improvements exist and should be implemented.

Journals that fail to make research discoverable breach the basic trust that researchers and their funders have in the current publishing system. Most funded researchers publish their work under the basic assumption that their journal or publisher is following best practices to ensure future use (61). Bodies funding health research have a responsibility to protect their investments and even more importantly, to ensure that funded research is not wasted by being published in non-credible and non-discoverable sources.

Data Availability

Open Science Framework: Audit of health research funder policies and recommendations on journal publication of research:

Protocol: https://doi.org/10.17605/OSF.IO/J6CSK64

Registration of overarching OSF project: https://doi.org/10.17605/OSF.IO/Z59U665

Study Forms, https://doi.org/10.17605/OSF.IO/FSUQ263

This project contains the following extended data:

Level 1 - Searching funder websites form 2017Nov23.pdf

Level 2 - Data extraction form 2017Nov23.pdf

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Author Contributions

The study was conceived of by LS, JG, and DM. LS drafted the initial protocol, with approval from the study team. LS managed the research project. LS, KDC, and MJP carried out the research. LS cleaned and analysed the data, prepared tables and figures, and drafted the manuscript. All authors provided feedback and gave their approval prior to submission.

Competing Interests

When this work was undertaken JMG (Trials), LAS and DM (Systematic Reviews) were Editors-in-Chief for the open access published Biomed Central, for which they received stipends'; MJP was an (unpaid) editorial board member for PLOS Medicine and Journal of Clinical Epidemiology; and LS was an (unpaid) associate editor for BMC Systematic Reviews.

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Tables and Figures

Table 1: Annual Expenditure across health research funders (in 2013 USD millions) by World Bank income level and type of funder.*

World Bank Income Level 2014	Type of Funder annual expenditure in 2013 USD millions (# of funders) [range]				
	Philanthropic	Public	Public-ODA	Multilateral	PPP
high income: non-OECD†	None listed	274.31(5)‡	None listed	None listed	None listed
high income: OECD	4995.25 (194)§	39847.47 (50)**	344.40 (8)	None listed	None listed
upper middle income	No data (1)	1540.87 (13)††	None listed	None listed	None listed
lower middle income	None listed	140.26 (4) ‡	None listed	None listed	None listed
low income	None listed	None listed	None listed	None listed	None listed
Income level not stated	None listed	6111.78 (5)	None listed	137.09 (7) **	455.36 (1)

* Created from data at healthresearchfunders.org
† OECD: Organisation for Economic Co-operation and Development
‡ Includes 3 funders with no expenditure data available
§ Includes 11 funders with no expenditure data available
** Includes 1 funder with no expenditure data available
†† Includes 5 funders with no expenditure data available

Table 2: Description of funders (n=44)

Descriptor		
Type of funder, n(%)	Philanthropic Public Public ODA Multilateral Public Private Partnership	15 (34%) 18 (41%) 7 (16%) 3 (7%) 1 (2%)
Country Income Level, n(%)	High income Upper-middle[i] Lower-middle[ii] Low income N/A[iii]	35 (80%) 1 (2%) 3 (7%) 0 (0%)[iv] 5 (11%)
Annual expenditures (in million 2013 USD), mean (n)	High income Upper-middle Lower-middle Low income[iv] N/A[iii]	$1,113.191 (35) $621.273 (1) $140.261 (1) - $862.024 (5)

[i] China

[ii] All funders from India

[iii] Income-level not available since funders distributing funds across multiple countries (3 multilateral funders and 2 European Union funders)

[iv] No funders from "Low income" countries in sample

Table 3: Funder Policies on publishing

		n(%)
Publicly available webpage or document(s) on funder website discussing dissemination of research outputs[a]		38 (86%)
Type of statement about research outputs[b,c]	Policy Recommendation/Guideline Other	29 (76%) 8 (21%) 1 (3%)[d]
Dissemination pertains to specific research output[b]	Research Data Other materials[e]	37 (97%) 25 (66%) 14 (39%)
Date of effect[f] [median (IQR)]		Sept 2014 (Apr 2012-Apr 2016)

[a] Denominator = 44 funders with grant guidelines

[b] Denominator = 38 funders with statements about research outputs

[c] Policy: uses the words "policy", "must", "require"; Recommendation/Guideline: uses the words "recommendation" "recommend", "suggest", "should", "guideline"

[d] Other - described as "Code of Conduct"

[e] Verbatim: activities of funded organizations; all research outputs, news releases; photos; any and all other published material referencing the research project or grant; code; research materials; protocols; research resources including, but are not limited to, the full range of tools that scientists and technicians use in the laboratory, such as cell lines, antibodies, reagents, animal models, growth factors, combinatorial chemistry, DNA libraries, clones and cloning tools (such as PCR), methods, laboratory equipment and machines; presentations; media interviews; and other professional activities; 'research tools'; metadata; bibliographic metadata; supplementary materials; other supporting artefacts, research resources/tools

[f] Out of 35 funders listing this information. Date of implementation was used if available, otherwise, date of document or last update was used. When only year was given, January was used as default month; when a date range was given the most recent date was used

Table 4: Funder position and information provided about journal publication of funded research (n=38)

		n (%)
Mentions journal publication of research outputs	Yes Mandatory Suggested/encouraged Can't tell No (but sharing of research mentioned)	36 (95%) 0 36 0 2 (5%)
Offers guidance on journal selection[1]	Yes No	13 (36%)[2] 23 (64%)
Mention of journals' or publishers' integrity or credibility.[1]	Yes No	6 (17%)[3] 30 (83%)
Journal practices or characteristics mentioned[1]	Open Access Journal Impact Factor (JIF) Any measure/description of journal quality[4] Peer review Any transparency or ethics standards Database indexing (excluding PMC) Other Nothing specific about journals mentioned	31 (86%) 0 4 (11%)[5] 30 (83%) 11 (31%)[6] 0 2 (6%)[7] 4 (11%)

[1] Denominator: 36 funders mentioning journal publication

[2] See Table 5 for verbatim text of statements about journal selection

[3] See Table 5 for verbatim text of statements about journal credibility

[4] excluding JIF

[5] 2 funders indicate journal should be "high quality, peer reviewed journal"; 1 funder indicates journal should be "quality peer-reviewed journal"; 1 funder indicates what a good journal is: "Good journals have guidelines for reviewers of manuscripts committing them to strict confidentiality/to disclose conflicts of interest and promise to respond to submitted manuscripts within a specified, short time limit, and correspondingly set their reviewers short time limits for their comments."

[6] See Table 6 for transparency or ethics standards for publications

[7] Other: 1 funder encourages publication in "primary scientific journals"; 1 funder states "models and mechanisms for publication and access to research must be both efficient and cost effective";

Table 5: Funder statements on journal selection, requirements & credibility

Funder	Journal Selection	Specific publisher/journal requirements or acceptability/credibility features	Name of webpage/source document
Bill & Melinda Gates Foundation	"Open access publishing is a non-negotiable term included in all grant agreements as of January 1, 2015. Please log into Chronos to search and find journals that offer open access options as required by the foundation's policy." "Our Open Access policy contains the following elements: 1. Publications Are Discoverable and Accessible Online. Publications will be deposited in a specified repository(s) with proper tagging of metadata. 2. Publication Will Be On "Open Access" Terms. All publications shall be published under the Creative Commons Attribution 4.0 Generic License (CC BY 4.0) or an equivalent license. This will permit all users of the publication to copy and redistribute the material in any medium or format and transform and build upon the material, including for any purpose (including commercial) without further permission or fees being required. 3. Foundation Will Pay Necessary Fees. The foundation would pay reasonable fees required by a	"Chronos will list the most current information about which journals offer these [open access] options, i.e., the listing for Science will reflect the current agreement between the Gates Foundation and the American Association for the Advancement of Science (AAAS)."	Open Access Policy - Frequently Asked Questions

	publisher to effect publication on these terms. 4. Publications Will Be Accessible and Open Immediately. All publications shall be available immediately upon their publication, without any embargo period. An embargo period is the period during which the publisher will require a subscription or the payment of a fee to gain access to the publication. We are, however, providing a transition period of up to two years from the effective date of the policy (or until January 1, 2017). During the transition period, the foundation will allow publications in journals that provide up to a 12-month embargo period..."		
Bloodwise	"If the journal is not compliant with our open access policy, grant holders can request from Bloodwise that grant underspend is used to cover the cost with a justification for publishing in a non-compliant journal"/"Researchers can determine which publishers are compliant with this policy by referring to the SHERPA/FACT database and checking against the Wellcome Trust's policy, which has the same stipulations."	None stated	Project grants – guidance for applicants
British Heart Foundation	All of our Grantholders submitting manuscripts to journals should find out in advance whether the publisher supports open access and how they can comply with paragraph 2 above.	None stated	Open Access Policies

Cancer Research UK	"The journal you publish in must be published by a publisher who has agreed to the COAF/Wellcome Trust publisher requirements. Cancer Research UK and the Charity Open Access Fund (COAF) will only fund APCs where the publisher has agreed to the COAF/Wellcome Trust publisher requirements. These publisher requirements set out the open access services that publishers must agree to provide when they charge APCs for COAF-funded researchers. Most major publishers and many smaller publishers have signed up to these requirements. If you would like to check that the publisher of your chosen journal is compliant, search the SHERPA/FACT database here. Select the name of the relevant journal and Cancer Research UK as your funder – as long as the results show at least one 'tick' (), the journal is compliant by that route."	"Publishers who want to provide open access publishing services for Wellcome and Charity Open Access Fund (COAF) grantholders through peer-reviewed journals based on article processing charges (APCs) must commit to providing a service that meets our requirements. Our open access policy (/funding/managing-grant/open-access-policy) states that when Wellcome funds are used to pay an APC, the article must be deposited, at the time of publication in PubMed Central (PMC). It will then be mirrored to Europe PMC. All deposited articles must be made available under the Creative Commons Attribution (CC-BY) Licence. COAF follows the same policy. Wellcome and COAF's open access policies and requirements are designed to maximise the availability and reuse of publications. We hope that publishers will continue to support us and our grantholders in this endeavour. We recognise that relationships in the publication process are not straightforward – we have grant-funding relationships with researchers, who then establish relationships with publishers. This can lead to confusion about what Wellcome and COAF expect from publishers.	Open Access Policy/Publisher Requirements

		Our requirements clarify the service that publishers who receive Wellcome or COAF funds need to provide."	
Deutsche Forschungsgemeinschaft /German Research Foundation	"The approved funds are only for the publication of essays in original Open Access journals. The funds may only be spent provided that the following conditions are met:…The articles to be published appear in journals whose contributions are all accessible to users free of charge ("genuine open access journals") immediately after their publication on the Internet, and which apply the strict quality assurance procedures recognized in the relevant subject… The funds provided by the DFG may not be used to publish open essays in journals subject to subscription (according to the "Open Choice" model etc.) for Open Access."* "Guiding ideas for choosing appropriate means of publication: http://thinkchecksubmit.org"	"Recommendation 12: Scientific journals shall make it clear in their guidelines for authors that they are committed to best international practice with regard to the originality of submitted papers and the criteria for authorship."/ "all good scientific journals report when a manuscript has been received and when – usually following peer review – it has been accepted"	Further information on Open Access
German Federal Ministry of Education and Research (BMBF)	"Scientific articles from projects funded by the BMBF should either be published directly under an open access model or be put into a suitable document server after expiry of an embargo deadline. The researchers remain free in their choice, whether and in which journal they want to publish"	None stated	Press Release announcing Open Access Strategy

Howard Hughes Medical Institute	"HHMI strongly encourages all HHMI laboratory heads to publish their original, peer-reviewed research in journals that make publications freely available and downloadable on-line immediately after publication (i.e. open access journals). If a laboratory head chooses to publish an original, peer-reviewed research publication on which he or she is a major author in a journal that is not open access, the laboratory head is responsible for ensuring that the publication is freely available and downloadable on-line as soon as reasonably possible after publication, and in any event within twelve months of publication."	None stated	Public Access to Publications
Indian Department of Biotechnology (DBT)	"The DBT and DST recognize the right of researchers to publish their work in journals of their choice, because researchers are the best judges of where to publish their work. The DBT and DST expect that the recipients of funding will publish their research in high quality, peer-reviewed journals." AND "Results should be published in an appropriate form, usually as papers in refereed journals, with copies being made available through PubMed Central (PMC) and UK PubMed Central (UKPMC) as soon as possible and in any event within six months of the journal publisher's official date of final publication."	None stated	DBT and DST Open Access Policy

Indian Department of Science & Technology (DST)	*same as Indian Department of Biotechnology (DBT)*	None stated	DBT and DST Open Access Policy
IDRC/Global Affairs Canada	"Authors should carefully consider the quality standards of publications and ensure that appropriate peer review mechanisms are followed. The Directory of Open Access Journals, maintained by Infrastructure Services for Open Access (IS4OA), lists open access journals that have been reviewed for quality. Authors can also refer to the information guide Publishing in Open Access Journals, which lists journal quality indicators to evaluate potential publication outlets."	While most open access journals are peer-reviewed and high quality, there are a number of questionable journals, i.e. journals that do not subscribe to most or any of the practices of legitimate, academic journals. There is no single rule or test to indicate whether an open access journal is reputable. But here is what you should look for and what you should be wary of to avoid publishing in a questionable journal: Look for ... • Journal scope is well-defined and clearly stated • Journal is affiliated with or sponsored by an established scholarly society or academic institution • Editor, editorial board are recognized experts in the field • Articles are within the scope of the journal and meet the standards of the discipline • Any publishing fees or charges are easily found on the journal website and clearly explained • Rights for use and re-use of content at article level (e.g., Creative Commons CCBY licence) are clearly indicated • Articles have DOIs (Digital Object Identifier, e.g., doi:10.1111/j.1742-9544.2011.00054.x) • An ISSN (International Standard Serial Number e.g. 1234-5678) has been assigned	Open Access Policy for IDRC-Funded Project Outputs/IDRC Publishing in Open Access Journals

		• Publisher is a member of Open Access Scholarly Publishers Association (OASPA) • Journal is listed in the Directory of Open Access Journals (DOAJ) • Journal is included in established subject databases and/or indexes (e.g., Academic Search Com- plete, Medline, etc.) Be wary of ... • No journal scope statement or one that is vague • Website mimics other well-known publishers' site, or links or uses logos of recognisable entities although there is no actual connection • Journal title is very similar to title of a more established journal • Poorly maintained Web presence, including dead links, multiple spelling and grammatical mis- takes (on website and in articles) • No editor, editorial board, or editorial staff is listed, or they lack affiliation • Publisher is also the editor of the journal and/or editorial boards members serve on the board of multiple titles from the same publisher • Authors have several articles in the same issue • Publisher uses direct and unsolicited marketing (i.e., spamming) or advertising is obtrusive (to publish articles or serve on editorial board)	

		• No information is provided about the publisher or location; either information is missing or does not match geographical area covered by the journal (e.g., "American Journal of …." but published in Croatia) • Instructions to authors regarding peer review, copyright and/or fees (APCs), are not listed on web- site or are unclear • Publisher promises unusually rapid peer review and publication schedule Open Access • New (but self-proclaimed "leading") publisher with a large number of journals • Journal not listed in the Directory of Open Access Journals (DOAJ) • Claims to be indexed by Google and Google Scholar (or other search engines that crawl the Web) • Refers to bogus metrics meant to mimic Impact Factor (e.g., Journal Influence Factor, Global Impact Factor, etc.) • Publisher has a negative reputation (e.g., documented examples in Chronicle of Higher Education, list-servs, etc.) • Journal or publisher appears on Beall's List of Predatory Journals and Publishers Tools to find and evaluate open access journals: • Directory of Open Access Journals: http://doaj.org/ Online index of open access, peer-reviewed journals • Beall's List of Predatory Journals and Publishers: http://scholarlyoa.com/ List of	

		potential, possible or probable questionable scholarly open access publishers and standalone journals • SHERPA/RoMEO: http://www.sherpa.ac.uk/romeo/ Online index of publisher copyright and self-archiving policies	
National Health & Medical Research Council (Australia)	"NHMRC acknowledges that researchers take into account a wide range of factors in deciding on the best outlets for publications arising from their research. Such considerations include the status and reputation of a journal, book, publisher or conference, the peer review process of evaluating their research outputs, access by other stakeholders to their work, the likely impact of their work on users of research and the further dissemination and production of knowledge. Taking heed of these considerations, NHMRC wants to ensure the widest possible dissemination of the research supported by NHMRC funding, in the most effective manner and at the earliest opportunity.	None stated	NHMRC OA policy
National Institutes of Health	"Awardees must ensure that any publishing agreement allows the paper to be posted to PMC in accordance with the NIH Public Access Policy. NIH does not dictate the means by which awardees must do so, but does offer guidance in an FAQ on suggested wording for publishing agreements."	"If a publication is in the journal section of the NLM catalog, NIH considers it to be a journal. Search the journal section of NLM Catalog (http://www.ncbi.nlm.nih.gov/nlmcatalog/journals) for the journal by title, title abbreviation, or ISSN. Automatic suggestions will display as you type. If the publication is not on the list, NIH will consider it a journal for policy purposes if it meets all of the	National Institutes of Health Plan for Increasing Access to Scientific Publications and Digital Scientific Data from NIH Funded Scientific Research/NIH FAQ

		following criteria: Publication must meet the requirements for ISSN assignment; Publication content is issued over time under a common title; Publication is a collection of articles by different authors; Publication is intended to be published indefinitely; You may also submit the manuscript to NIHMS upon acceptance for publication for a determination."	on Public Access Policy
Wellcome Trust	"We expect Wellcome-funded researchers to select publishing routes that ensure the work is available immediately on publication in its final published form, wherever such options exist for their publisher of choice and are compliant with our policy." "The [Charitable Open Access Fund] fund can only be used for APCs where the publisher has agreed to our publishing requirements." "Check that your journal of choice has a publishing policy compliant with our grant conditions. Wellcome-funded authors can use the SHERPA Funders' and Authors' Compliance Tool (http://www.sherpa.ac.uk/fact/) (SHERPA FACT) to check this."	*Same as Cancer Research UK*	Open Access Policy/Publisher Requirements

* "Open Choice" is a term used by the publisher *Springer* to refer to hybrid journals

Table 6: Transparency tools/activities mentioned by funders

Funder	Additional publication transparency actions/initiatives mentioned	Source
Bill & Melinda Gates Foundation	"Publications Are Discoverable and Accessible Online: Publications will be deposited in a specified repository(s) with proper tagging of metadata."	Open Access Policies
Bloodwise (formerly Leukaemia & Lymphoma Research)	"Grant holders should make use of the ARRIVE guidelines when designing their experiments, and ensure that they report in vivo studies in accordance with the ARRIVE guidelines as far as possible."	Project Grants Guidance
Deutsche Forschungsgemeinschaft / German Research Foundation	Recommendation 7: Safeguarding and Storing of Primary Data. "Experiments and numerical calculations can only be repeated if all important steps are reproducible. For this purpose, they must be recorded. Every publication based on experiments or numerical simulations includes an obligatory chapter on "materials and methods" summing up these records in such a way that the work may be reproduced in another laboratory."	Safeguarding Good Scientific Practice
European Commission	"To be able to easily find the deposited publication, beneficiaries must also ensure open access – via the repository – to the bibliographic metadata that identify the deposited publication. This metadata must include a persistent identifier (such as the Digital Object Identifier, DOI) in order to allow easy and persistent referencing."	European Research Council (ERC) Guidelines on Implementation of Open Access to Scientific Publications and Research Data
Indian Council of Medical Research	Researcher's Relations with the Media and Publication Practices: "The term 'misconduct in research' means fabrication, falsification, plagiarism, selective omission of data and claiming that some data are missing, ignoring outliers without declaring it, not reporting data on side effects/ adverse reactions in a clinical trial, publication of post-hoc analysis without declaring it, gift authorship, not citing others' work, not disclosing conflict of interest,	Ethical Guidelines for Biomedical Research on Human Participants

	redundant publication, and failure to adequately review existing research. The Commission on Research Integrity in US created by US Congress addresses the scientific, ethical, social and legal issues involving scientific misconduct in research. Consolidated standards of reporting trials (CONSORT) guidelines have been prescribed for publishing results of clinical research especially RCTs (Randomised Controlled Trials) and are available at http://www.consortstatement. org.	
Institut Pasteur	"To be able to easily find the deposited publication, beneficiaries must also ensure open access – via the repository – to the bibliographic metadata that identify the deposited publication. This metadata must include a persistent identifier (such as the Digital Object Identifier, DOI) in order to allow easy and persistent referencing."	European Research Council (ERC) Guidelines on Implementation of Open Access to Scientific Publications and Research Data
Medical Research Council (UK Research and Innovation since 2018)	G.8. Reporting Guidelines: "Agreed standards for reporting the outcomes of research in specific areas have been developed and should be observed. Standards endorsed and supported by the MRC include the CONSORT Statement (CONsolidated Standards of Reporting Trials) (46) and the ARRIVE guidelines (Animal Research: Reporting in-vivo experiments) (47)."	MRC ethics series. Good research practice: Principles and guidelines
NIH	5.a. Access & Discoverability: Meta Data. "Ensure full public access to publications' metadata without charge upon first publication in a data format that ensures interoperability with current and future search technology. Where possible, the metadata should provide a link to the location where the full text and associated supplemental materials will be made available after the embargo period; Ensure that attribution to authors, journals, and original publishers is maintained (OSTP memo, elements 3c, 3e)"	Plan for Increasing Access to Scientific Publications and Digital Scientific Data from NIH Funded Scientific Research
U.S. Agency for International Development	"Metadata [from a research dataset or publication] should be made accessible as soon as possible after final	Public Access Plan

	acceptance of a paper and appropriate review, even if the full text is subject to an embargo period."	
World Bank	"Requires electronic copies of complete, final manuscripts, as defined above, as well as the associated metadata, to be deposited in the Open Knowledge Repository"	World Bank Open Access Policy for Formal Publications
World Health Organization	Summary of the open-access policy options and requirements: "Publisher deposits XML version of the article and metadata in PubMed Central, which automatically appear in Europe PubMed Central"	WHO open-access policy: Frequently asked questions for recipients of WHO funding

Table 7: Monitoring and consequences

Funder Name	Adherence-monitoring strategy	Consequences for non-adherence
American Heart Association	(From OA policy) "In situations where the AHA or members of the research community feel that AHA-funded researchers are not sharing data in a manner consistent with our policy, you may be asked by the AHA to demonstrate your compliance."	"If you cannot do so [demonstrate compliance with OA policy], this may affect future funding."
Bill & Melinda Gates	(From FAQ about OA Policy) "The foundation checks and tracks compliancy through Chronos, a new service to help you manage the process of publishing under the policy's terms."	*None stated/identified*
Canadian Institutes for Health Research	*Nothing stated/identified*	*not specific to journal publication - but have consequences for breaches in policy, including breaches around dissemination of research*
Centers for Disease Control and Prevention	(From…) " Supervisors of publishing authors are responsible for ensuring compliance with the CDC Public Access Policy."	*None stated/identified*
Institut Pasteur	(From OA intentions) "The deposit is checked by the CeRIS library's Hal team, in particular when it comes to the rights of authors on their files and their affiliations to a lab and and institution."	*None stated/identified*
JRDF	*Nothing stated/identified*	(From Award Terms and Conditions) *not specific to publication* "JDRF may place the PI and/or his/her Grantee Institution on administrative probation if …the Grantee Institution is non-compliant as outlined in this document. JDRF administrative probation may include, but is not limited to, the following actions: 1. Withholding of all payments for the grant/project in question 2. Changing to a payment reimbursement schedule 3. Withholding of all JDRF payments for the PI, for any JDRF grant 4.

		Withholding of all JDRF payments for the Grantee Institution, for any JDRF grant 5. Any combination of the above"
National Institutes of Health	(NIH Public Access Policy) "Compliance with this Policy remains a statutory requirement and a term and condition of the grant award and cooperative agreement, in accordance with the NIH Grants Policy Statement."	(NIH Public Access Policy - FAQ) "A grantee's failure to comply with the terms and conditions of award may cause NIH to take one or more enforcement actions, depending on the severity and duration of the non-compliance. NIH will undertake any such action in accordance with applicable statutes, regulations, and policies. NIH generally will afford the grantee an opportunity to correct the deficiencies before taking enforcement action unless public health or welfare concerns require immediate action. However, even if a grantee is taking corrective action, NIH may take proactive action to protect the Federal government's interests, including placing special conditions on awards or precluding the grantee from obtaining future awards for a specified period, or may take action designed to prevent future non-compliance, such as closer monitoring. See Enforcement Actions in the NIH Grants Policy Statement (10/12).."
Pan American Health Organisation	"Research commitments shall be reflected in institutional policies and program budgeting and planning, implementation, monitoring, and evaluation; human resource management; and knowledge management."	*None stated/identified*
UK Department for International Development	(From DFID Research Open and Enhanced Access Policy) "As part of its monitoring and evaluation framework, DFID Research and Evidence Division (RED) collects data on the extent to which researchers fulfil the requirements and recommendations of this policy. RED researchers are required to	*None stated/identified*

	report open access activity, usually during the annual review."	
US Agency for International Development	(From Public Access Plan) "Potential future monitoring plans are suggested: "Further criteria/metrics for compliance and evaluation will be developed through consultations with M/OAA/P, GC, and other USAID Operating Units. This may include: A) requesting offerors to submit within their proposals a list of USAID-funded peer-reviewed publications (and the corresponding DEC-issued unique identifier number for publication) that resulted from their prior USAID awards when deemed appropriate by the CO; B) importing the metadata and links to the authors' manuscript or the publically available version of record of publications that resulted from USAID support, but were published after completion of the award in partnership with third-party reference services such as CHORUS and FundRef; and C) including compliance with open data and public access requirements of awards as a measure of past performance."	*None stated/identified*
Wellcome Trust	(From Complying with our OA policy) "We actively monitor research papers authored by our funded researchers to ensure they comply with our policy. This includes the review of publications listed in ongoing grant reporting and in end of grant reports. In addition, Wellcome-funded research papers detailed in applications submitted to us are reviewed to ensure compliance."	(From Complying with our OA policy) "When Wellcome-funded researchers do not comply with our open access policy, we will apply these sanctions: Applicants will be required to ensure that all their Wellcome-funded original research papers resulting from current or previous grants are compliant before we issue formal notification of any funding renewals or new grants. Where non-compliant research papers, book chapters and scholarly monographs are identified in an end of grant report, we will withhold the final 10 per cent of the total grant budget

		until all outputs comply. See our 10 per cent retention policy."

Box 1 Recommendations for providing explicit/transparent guidance on journal selection in health research funders' open access policies

1. Use precise wording to describe your agency's expectations that funded research be published
    1. Indicate whether researchers are expected to publish their research (e.g. use of "must" vs "should")
    2. indicate whether open access publication is one of several options for meeting the agency's open access requirements.
2. Provide a definition of a journal that is suitable to your agency
    - Decide what essential features a publishing entity should and should not have in order to be considered a suitable place for publication.
    - Consider referring to/including the Committee on Publication Ethics (COPE) list of Core Practices all journals and publishers should follow: https://publicationethics.org/core-practices
    - The NIH definition of a journal is (47):
        - Publication meets the requirements for ISSN (International Standard Serial Number) assignment;
        - Publication content is issued over time under a common title;
        - Publication is a collection of articles by different authors;
        - Publication is intended to be published indefinitely.
3. Indicate your agency's requirements for access and discoverability of published articles
    - Distinguish between free vs open access:
        - Published articles are free to access; AND additionally, for open access,
        - Licensing for published articles permit reuse and building on (typically through a Creative Commons Attribution License, CC BY).
    - Ensure that published research can be accessed in perpetuity
        - Researchers can determine whether the publishing journal has a permanent archival arrangement in place either through automatic deposition to PMC (https://www.ncbi.nlm.nih.gov/pmc/journals/), or to another archive (via the Keepers Registry: https://keepers.issn.org/keepers-registry)[xxv]
        - PMC-partnered funders can require that researchers upload published research directly to PMC
    - Journal provides unique permanent identifiers (e.g. digital object identifier [DOI]) (can check if journal/publisher is registered with CrossRef: https://www.crossref.org/06members/51depositor.html)
4. Be clear about your agency's support for article processing charges arising from publication of funded research
    - Indicate how much money is available each open access publication (e.g. maximum APC amount)
    - Indicate who will receive APC payment from the funder – the author (institution) or the journal
    - Indicate when funding will be distributed to support article processing charges
    - Indicate whether there are any conditions on distribution of APC funds
5. Indicate whether your agency requires archiving in a repository alongside publication
    - Indicate whether the publication, data, or both, are expected to be deposited in a repository
    - Indicate when deposition is expected to occur (i.e., immediately or within a specified time frame)

- Indicate whether you have a dedicated repository for research publications (e.g., PMC for NIH-funded research), and if not, suggest one or more repositories that are considered acceptable by your agency
- Be clear that it is the authors' responsibility to ensure publications are deposited in a repository
- Provide instructions/link to resources on how to deposit research in the suggested repository.

6. Indicate how your agency will monitor that funded research is published in appropriate journals, in line with agency recommendations/mandates
   - For ease of monitoring, Provide instructions for researchers about where and how to include the funding agency name and grant number in published articles (guidance here: http://www.rin.ac.uk/system/files/attachments/Acknowledgement-funders-guidance.pdf)
   - Provide instructions on if, how, and when to submit publications of funded research to the funding agency, or state how publications will be monitored otherwise
   - Provide specific actions/consequences that the agency will carry out when funded research is published in a journal that does not meet agency requirements

[xxv] provides global monitoring of archiving arrangements for electronic journals

Table 8: Resources and tools that funders can use to support development of, adherence to, and monitoring of open access publishing policies

Resource/Tool	URL	Origin	Description	Relevance & Implementation	Limitations
CHORUS	https://www.chorusaccess.org/	Association of American Publishers	A service that utilizes metadata from CrossRef Funder Registry and partner publishers to monitor the # of published articles and % that are freely accessible; prompts free article access if required by funder policies; ensures digital preservation.	FACILITATING ADHERENCE & MONITORING: Encourage researchers to include funder name and grant number in published articles. Ensure funder information is registered and correct in CrossRef Funding Registry.	Fee-based Only able to facilitate open access & preservation for publisher partners (paid service).
Chronos	https://chronos-oa.com/	The Bill & Melinda Gates Foundation	A service facilitating funders' management and tracking of the publication process for funded research outputs, through which pay APCs, and by which to manage subsequent archiving. Automatically collects information on where research was published, whether, when, and in which repositories published research and data were deposited, and the type of license research was published under.	FACILITATE ADHERNCE: Require that researchers use Chronos to submit any funder-supported research for publication; pay APCs directly to publishers instead of distributing as grant funding. MONITOR ADHERENCE: Use to monitor # of open access publications. Use as grant reporting tool to alleviate researchers of administrative responsibility.	Fee-based Only tracks publications submitted through Chronos.
CrossRef Funder Registry[xxvi]	https://search.crossref.org/funding	CrossRef	Tracks any published articles with a digital object identifier (DOI) issued by Crossref (main DOI registration organization) and for which funder metadata is available	MONITOR ADHERENCE: Ensure funder information is registered and correct in the Registry; use to search for publications and other research outputs with DOIs	No distinction between freely available vs. subscription content. Only able to track articles for which

				funded by a specific grant or by a funder overall.	publishers have registered DOIs and funding metadata with Crossref (paid service). Dependent on authors reporting funding information during the submission process or on publishers extracting from article.
HowOpenIsIt? Guide to Research Funder Policies	http://www.orfg.org/policy-development-guide/	Open Research Funders Group; SPARC	Freely available framework for designing funders' open access policies. Provides policy examples along a spectrum of openness for five aspects of research outputs: article access, data and code access, reuse, costs, and compliance.	POLICY DEVELOPMENT: Use to facilitate design of a policy that includes recommendations on one or more aspects of openness of research outputs, that are feasible/desired.	None
OpenAire	https://monitor.openaire.eu/	European Commission/ Horizon 2020	Uses metadata provided by a funder (i.e., grant number) to search for funded research outputs deposited in digital archives/repositories.	MONITOR ADHERENCE: Use to collect data on research outputs (including publications) that are available in repositories.	Only sees freely available outputs. Dependent on researchers including grant numbers within research outputs deposited in repositories. Relies on repositories being compliant/providing necessary metadata.
PubMed Central (PMC)	https://www.ncbi.nlm.nih.gov/pmc	NIH	The US National Library of Medicine's (NLM) repository of freely available, full-text,	FACILITATE ADHERNCE: Take appropriate steps to partner with PMC, Europe PMC, or	Relies on journals agreeing to deposit to PMC or on authors to

			published biomedical and life sciences articles; Dedicated repository for published NIH-funded research and for select other US and international funders. Publications can be deposited by journals with agreements with PMC or by researchers reporting NIH (or other agreed funder-) supported research.	the Health Research Alliance (NLM partner): https://www.ncbi.nlm.nih.gov/pmc/about/public-access/. Require that all publications from funded research are deposited in PMC via a publishing journal or by authors.	deposit published research for journals without PMC agreements.
SHERPA/FACT (Funder & Author Compliance Tool)	http://sherpa.ac.uk/fact/	Jisc; Wellcome Trust; Research Councils UK	Free online tool for researchers funded by the Wellcome Trust and members of Research Councils UK to check whether their intended journal meets funder open access requirements.	FACILITATE ADHERNCE: Request inclusion to be listed in FACT from Jisc. Direct funded researchers to use FACT to select a journal in which to publish in.	Relies on authors to use. Restricted to searching journals for which open access policies that have been collected
Think, Check, Submit	https://thinkchecksubmit.org	Publishing community led (collaboration among many publishing professionals/ organizations)	Freely available checklist to facilitate researchers in selecting a relevant and trustworthy journal in which to submit their research for publication consideration	FACILITATE ADHERNCE: Encourage authors to use checklist to facilitate selection of credible journal.	Relies on authors to read/understand/use Uncertain development process and validity of checklist items.

[xxvi] Previously known as FundRef (until Nov 2015)

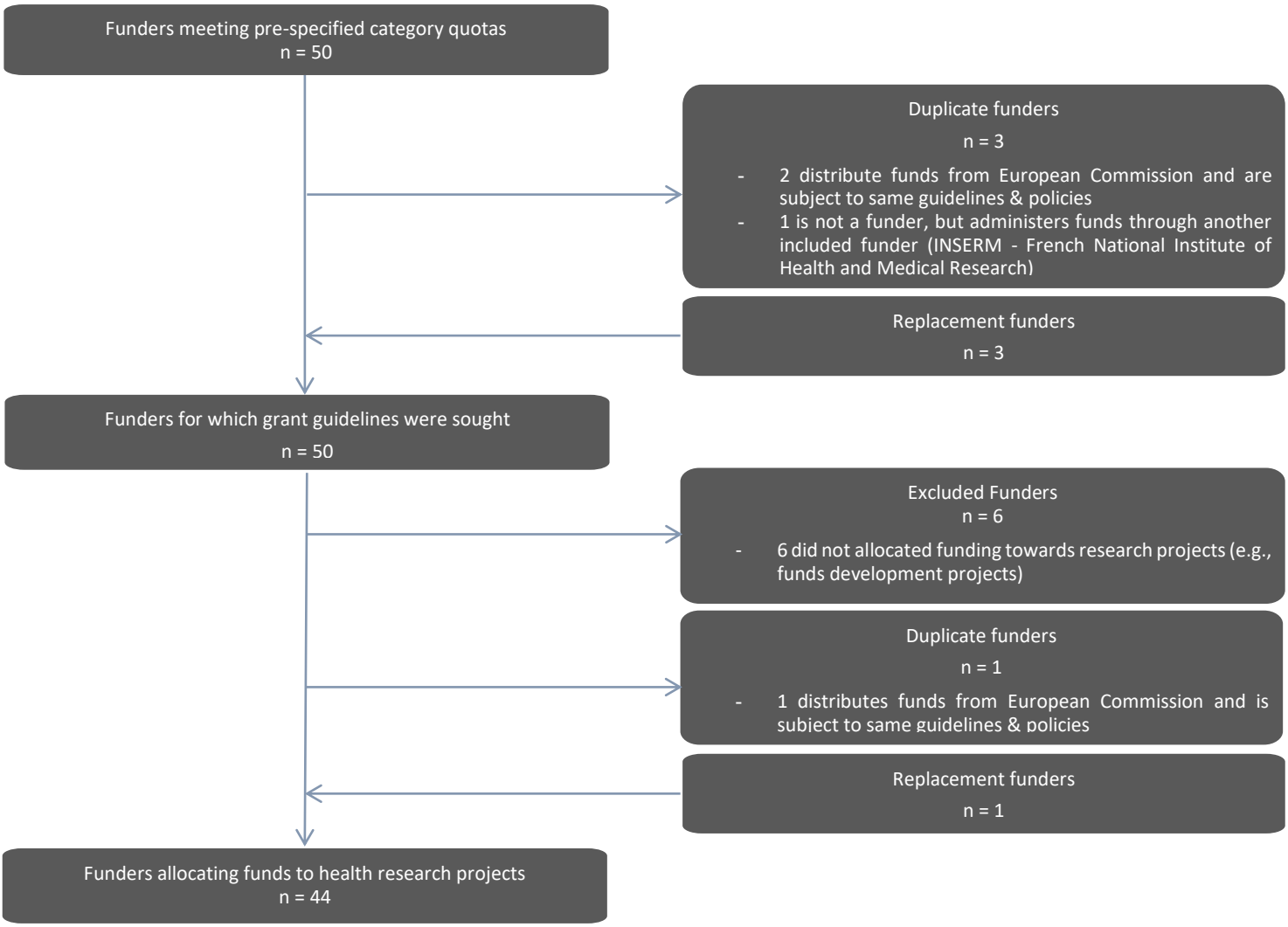

Figure 1: Flow diagram for selection of included funders

References

1. Moher D, Shamseer L, Cobey KD, Lalu MM, Galipeau J, Avey MT, et al. Stop this waste of people, animals and money. Nature. 2017 Sep 7;549(7670):23–5.

2. Beall J. Predatory publishers are corrupting open access. Nature. 2012;489:179.

3. Van Dyck C. The Long-Term Preservation of Open Access Journals [Internet]. DOAJ News Service. 2018 [cited 2019 Oct 23]. Available from: https://blog.doaj.org/2018/09/17/the-long-term-preservation-of-open-access-journals/

4. Macleod MR, Michie S, Roberts I, Dirnagl U, Chalmers I, Ioannidis JPA, et al. Biomedical research: increasing value, reducing waste. Lancet. 2014 Jan 11;383(9912):101–4.

5. Lane J. Let's make science metrics more scientific. Nature. 2010 Mar;464(7288):488–9.

6. Macilwain C. Science economics: What science is really worth. Nature. 2010 Jun 10;465(7299):682–4.

7. Larivière V, Sugimoto CR. Do authors comply when funders enforce open access to research? Vol. 562, Nature. NLM (Medline); 2018. p. 483–6.

8. Suber P. Open Access Overview. Focusing on open access to peer-reviewed research articles and their preprints [Internet]. 2015 [cited 2017 Sep 29]. Available from: http://legacy.earlham.edu/~peters/fos/overview.htm

9. US National Institutes of Health. How Papers Get Into PMC [Internet]. 2015 [cited 2020 Jan 24]. Available from: https://www.ncbi.nlm.nih.gov/pmc/about/submission-methods/

10. US National Institutes of Health. PMC and Research Funder Policies [Internet]. 2019 [cited 2020 Jan 24]. Available from: https://www.ncbi.nlm.nih.gov/pmc/about/public-access/

11. PMC E. Funders - About - Europe PMC [Internet]. [cited 2020 Jan 24]. Available from: http://europepmc.org/Funders/

12. Moher D, Srivastava A. You are invited to submit…. BMC Med. 2015 Dec;13(1):180.

13. Clemons M, de Costa e Silva M, Joy AA, Cobey KD, Mazzarello S, Stober C, et al. Predatory Invitations from Journals: More Than Just a Nuisance? Oncologist. 2017 Feb;22(2):236–40.

14. Nelson N, Huffman J. Predatory Journals in Library Databases: How Much Should We Worry? Ser Libr. 2015 Aug 18;69(2):169–92.

15. Somoza-Fernández M, Rodríguez-Gairín J-M, Urbano C. Presence of alleged predatory journals in bibliographic databases: Analysis of Beall's list. El Prof la Inf. 2016 Oct 11;25(5):730.

16. Topper L. RE: How predatory journals leak into PubMed [Internet]. CMAJ. 2018 [cited 2020 Jan 8]. Available from: https://www.cmaj.ca/content/re-how-predatory-journals-leak-pubmed

17. Manca A, Moher D, Cugusi L, Dvir Z, Deriu F. How predatory journals leak into PubMed. CMAJ. 2018 Sep 4;190(35):E1042–5.

18. US National Library of Medicine. Fact Sheet MEDLINE® Journal Selection [Internet]. U.S. National Library of Medicine; [cited 2019 Dec 5]. Available from: https://www.nlm.nih.gov/lstrc/jsel.html

19. DOAJ. APPLICATIONS: A NOTE ABOUT ARCHIVING AND PRESERVATION. DOAJ Blog. 2015.

20. Carpenter J. Researchers of Tomorrow: The research behaviour of Generation Y doctoral students. Hlava MMK, editor. Vol. 32, Information Services & Use. 2012 Nov.

21. Dallmeier-Tiessen S, Darby R, Goerner B, Hyppoelae J, Igo-Kemenes P, Kahn D, et al. Highlights from the SOAP project survey. What Scientists Think about Open Access Publishing. Arxiv. 2011 Jan 27;1101.5260.

22. Charbonneau DH, McGlone J. Faculty experiences with the National Institutes of Health (NIH) public access policy, compliance issues, and copyright practices. J Med Libr Assoc. 2013;101(1):21–5.

23. Neylon C. Science publishing: Open access must enable open use. Vol. 492, Nature. 2012. p. 348–9.

24. Shamseer L, Moher D, Maduekwe O, Turner L, Barbour V, Burch R, et al. Potential predatory and legitimate biomedical journals: can you tell the difference? A cross-sectional comparison. BMC Med. 2017 Dec 16;15(1):28.

25. Court Rules in FTC's Favor Against Predatory Academic Publisher OMICS Group; Imposes $50.1 Million Judgment against Defendants That Made False Claims and Hid Publishing Fees [Internet]. Federal Trade Commission Press Releases. 2019 [cited 2019 Jun 10]. Available from: https://www.ftc.gov/news-events/press-releases/2019/04/court-rules-ftcs-favor-against-predatory-academic-publisher-omics

26. Shen C, Bjork B-C, Björk B. 'Predatory' open access: a longitudinal study of article volumes and market characteristics. BMC Med. 2015 Dec 1;13(1):230.

27. Bjork B-C, Solomon D. The publishing delay in scholarly peer-reviewed journals. J Inf. 2013;7:914–23.

28. Van Noorden R. Gates Foundation research can't be published in top journals. Nature. 2017 Jan 19;541(7637):270–270.

29. Van Noorden R. Science journals permit open-access publishing for Gates Foundation scholars. Nature. 2017 Feb 14;

30. Van Noorden R. Science journals end open-access trial with Gates Foundation. Nature. 2018 Jul 13;559(7714):311–2.

31. Nasser M, Clarke M, Chalmers I, Brurberg KG, Nykvist H, Lund H, et al. What are funders doing to minimise waste in research? Lancet. 2017 Mar 11;389(10073):1006–7.

32. DeVito NJ, French L, Goldacre B. Noncommercial Funders' Policies on Trial Registration, Access to Summary Results, and Individual Patient Data Availability. JAMA. 2018 Apr 24;319(16):1721.

33. Viergever RF, Hendriks TCC. The 10 largest public and philanthropic funders of health research in the world: what they fund and how they distribute their funds. Heal Res policy Syst. 2016 Feb;14:12.

34. Whitlock EP, Dunham KM, DiGioia K, Lazowick E, Gleason TC, Atkins D. Noncommercial US Funders' Policies on Trial Registration, Access to Summary Results, and Individual Patient Data Availability. JAMA Netw open. 2019 Jan 4;2(1):e187498.

35. Xia J, Harmon JL, Connolly KG, Donnelly RM, Anderson MR, Howard HA. Who publishes in "predatory" journals? J Assoc Inf Sci Technol. 2015 Jul;66(7):1406–17.

36. Goldacre B. The WHO joint statement from funders on trials transparency. BMJ. 2017 Jun 19;357:j2816.

37. Jackson JL, Kuriyama A, Anton A, Choi A, Fournier J-P, Geier A-K, et al. The Accuracy of Google Translate for Abstracting Data From Non–English-Language Trials for Systematic Reviews. Ann Intern Med. 2019 Nov 5;171(9):677.

38. Dwan K, Gamble C, Williamson PR, Altman DG. Reporting of clinical trials: a review of research funders' guidelines. Trials. 2008 Dec 25;9(1):66.

39. Osei K, Adjei K, Mfum Owusu-Ansah C. PUBLISHING PREFERENCES AMONG ACADEMIC RESEARCHERS: IMPLICATIONS FOR ACADEMIC QUALITY AND INNOVATION. 2016.

40. Wakeling S, Spezi V, Fry J, Creaser C, Pinfield S, Willett P. Academic communities. J Doc. 2019 Jan 14;75(1):120–39.

41. Topper L, Boehr D. Publishing trends of journals with manuscripts in pubmed central: Changes from 2008–2009 to 2015–2016. J Med Libr Assoc. 2018 Oct 1;106(4):445–54.

42. Wellcome updates open access policy to align with cOAlition S | Wellcome [Internet]. [cited 2019 Oct 27]. Available from: https://wellcome.ac.uk/news/wellcome-updates-

open-access-policy-align-coalition-s

43. Peterson AT, Johnson PE, Barve N, Emmett A, Greenberg ML, Bolick J, et al. The NIH public access policy did not harm biomedical journals. PLOS Biol. 2019 Oct 23;17(10):e3000352.

44. National Institutes of Health (NIH). NOT-OD-18-011: Statement on Article Publication Resulting from NIH Funded Research [Internet]. [cited 2018 Jan 15]. Available from: https://grants.nih.gov/grants/guide/notice-files/NOT-OD-18-011.html

45. Lalu MMMM, Shamseer L, Cobey KDKD, Moher D. How stakeholders can respond to the rise of predatory journals. Nat Hum Behav. 2017 Dec 4;1(12):852–5.

46. Tenopir C, Dalton E, Fish A, Christian L, Jones M, Smith M. What Motivates Authors of Scholarly Articles? The Importance of Journal Attributes and Potential Audience on Publication Choice. Publications. 2016 Jul 18;4(3):22.

47. National Institutes of Health. Plan for Increasing Access to Scientific Publications and Digital Scientific Data from NIH Funded Scientific Research. 2015.

48. Morris S. The true costs of scholarly journal publishing. Learn Publ. 2005 Apr;18(2):115–26.

49. Berger M, Cisarella J. Beyond Beall's List: Better understanding predatory publishers. Coll Res Libr News. 2015;76(3):132–5.

50. Tao T. India's Fight Against Predatory Journals: An Interview with Professor Bhushan Patwardhan [Internet]. The Scholarly Kitchen. 2020 [cited 2020 May 1]. Available from: https://scholarlykitchen.sspnet.org/2020/02/05/indias-fight-against-predatory-journals-an-interview-with-professor-bhushan-patwardhan/

51. Patwardhan B, Nagarkar S, Gadre SR, Lakhotia SC, Katoch VM, Moher D. A critical analysis of the 'UGC-approved list of journals'. Curr Sci. 2018;114(6):1299–303.

52. Patwardhan B. Why India is striking back against predatory journals. Nature. 2019 Jul;571(7763):7–7.

53. Graham ID, Logan J, Harrison MB, Straus SE, Tetroe J, Caswell W, et al. Lost in knowledge translation: time for a map? J Contin Educ Health Prof. 2006 Jan;26(1):13–24.

54. Michie S, Richardson M, Johnston M, Abraham C, Francis J, Hardeman W, et al. The Behavior Change Technique Taxonomy (v1) of 93 Hierarchically Clustered Techniques: Building an International Consensus for the Reporting of Behavior Change Interventions. Ann Behav Med. 2013 Aug 20;46(1):81–95.

55. Anderson K. Lessons from the Demise of PubMed Central Canada [Internet]. Caldera Publishing Solutions. 2018 [cited 2020 Jan 9]. Available from: http://www.caldera-publishing.com/blog/2018/1/4/lessons-from-the-demise-of-pubmed-central-canada

56. Seethapathy GS, Santhosh Kumar JU, Hareesha AS. India's scientific publication in predatory journals: need for regulating quality of Indian science and education. Curr Sci. 2016;111(11):1759–64.

57. Kolata G. Many Academics Are Eager to Publish in Worthless Journals [Internet]. The New York Times. 2017 [cited 2020 Apr 30]. Available from: https://www.nytimes.com/2017/10/30/science/predatory-journals-academics.html?smid=tw-share

58. Bagues M, Sylos-Labini M, Zinovyeva N. A walk on the wild side: 'Predatory' journals and information asymmetries in scientific evaluations. Res Policy. 2019 Mar;48(2):462–77.

59. Cappell MS. List predatory journal publications separately from genuine scholarly publications as standard for CVs. BMJ. 2015;350.

60. Pond BB, Brown SD, Stewart DW, Roane DS, Harirforoosh S. Faculty applicants' attempt to inflate CVs using predatory journals. Vol. 83, American Journal of Pharmaceutical Education. American Association of Colleges of Pharmacy; 2019.

61. Price DJ de S. Little science, big science. Columbia Univ. Press; 1963. 119 p.

Appendix 1: Author Contributions

The study was conceived of by LS, JG, and DM. LS drafted the initial protocol, with approval from the study team. LS managed the research project. LS, KDC, and MJP carried out the research. LS cleaned and analysed the data, prepared tables and figures, and drafted the manuscript. All authors provided feedback and gave their approval prior to submission.

#	Role	Author(s)	Definition
1	Conceptualization	LS, DM, JG	Ideas; formulation or evolution of overarching research goals and aims.
2	Data curation	LS	Management activities to annotate (produce metadata), scrub data and maintain research data (including software code, where it is necessary for interpreting the data itself) for initial use and later re-use.
3	Formal analysis	LS	Application of statistical, mathematical, computational, or other formal techniques to analyse or synthesize study data.
4	Funding acquisition	n/a – not funded	Acquisition of the financial support for the project leading to this publication.
5	Investigation	LS, KDC, MJP	Conducting a research and investigation process, specifically performing the experiments, or data/evidence collection.
6	Methodology	LS	Development or design of methodology; creation of models.
7	Project administration	LS	Management and coordination responsibility for the research activity planning and execution.
8	Resources	DM	Provision of study materials, reagents, materials, patients, laboratory samples, animals, instrumentation, computing resources, or other analysis tools.

9	Software	n/a	Programming, software development; designing computer programs; implementation of the computer code and supporting algorithms; testing of existing code components.
10	Supervision	LS, DM, JG	Oversight and leadership responsibility for the research activity planning and execution, including mentorship external to the core team.
11	Validation	LS, KDC, MJP	Verification, whether as a part of the activity or separate, of the overall replication/reproducibility of results/experiments and other research outputs.
12	Visualization	LS	Preparation, creation and/or presentation of the published work, specifically visualization/data presentation.
13	Writing – original draft	LS	Preparation, creation and/or presentation of the published work, specifically writing the initial draft (including substantive translation).
14	Writing – review & editing	LS, KDC, MJP, JCB, JG, DM, LAS, SES	Preparation, creation and/or presentation of the published work by those from the original research group, specifically critical review, commentary or revision – including pre- or post-publication stages.

Appendix 2: Published Article

RESEARCH ARTICLE

Top health research funders' guidance on selecting journals for funded research [version 1; peer review: awaiting peer review]

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Abstract

Background: Funded health research is being published in journals that many regard as "predatory", deceptive, and non-credible. We do not currently know whether funders provide guidance on how to select a journal in which to publish funded health research.
Methods: We identified the largest 46 philanthropic, public, development assistance, public-private partnership, and multilateral funders of health research by expenditure, globally as well as four public funders from lower-middle income countries, from the list at https://healthresearchfunders.org. One of us identified guidance on disseminating funded research from each funders' website (August/September 2017), then extracted information about selecting journals, which was verified by another assessor. Discrepancies were resolved by discussion. Results were summarized descriptively. This research used publicly available information; we did not seek verification with funding bodies.
Results: The majority (44/50) of sampled funders indicated funding health research. 38 (of 44, 86%) had publicly available information about disseminating funded research, typically called "policies" (29, 76%). Of these 38, 36 (95%) mentioned journal publication for dissemination of which 13 (36.11%) offer variable guidance on selecting a journal, all of which relate to the funder's open access mandate. Six funders (17%) outlined publisher requirements or features by which to select a journal. One funder linked to a document

Open Peer Review

Reviewer Status *AWAITING PEER REVIEW*

Any reports and responses or comments on the article can be found at the end of the article.

providing features of journals to look for (e.g. listed in the Directory of Open Access Journals) and to be wary of (e.g., no journal scope statement, uses direct and unsolicited marketing).
Conclusions: Few funders provided guidance on how to select a journal in which to publish funded research. Funders have a duty to ensure that the research they fund is discoverable by others. This research is a benchmark for funder guidance on journal selection prior to the January 2021 implementation of Plan S (a global, funder-led initiative to ensure immediate, open access to funded, published research).

Keywords
journals, journal selection, health research funders, publishing

This article is included in the Science Policy Research gateway.

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Author roles: Shamseer L: Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Project Administration, Supervision, Validation, Visualization, Writing – Original Draft Preparation, Writing – Review & Editing; **Cobey KD**: Conceptualization, Investigation, Validation, Writing – Review & Editing; **Page MJ**: Conceptualization, Investigation, Validation, Writing – Review & Editing; **Brehaut JC**: Conceptualization, Writing – Review & Editing; **Grimshaw JM**: Conceptualization, Methodology, Writing – Review & Editing; **Straus SE**: Conceptualization, Writing – Review & Editing; **Stewart LA**: Conceptualization, Writing – Review & Editing; **Moher D**: Conceptualization, Methodology, Resources, Writing – Review & Editing

Competing interests: When this work was undertaken JMG (Trials), LAS and DM (Systematic Reviews) were Editors-in-Chief for the open access published Biomed Central, for which they received stipends'; MJP was an (unpaid) editorial board member for PLOS Medicine and Journal of Clinical Epidemiology; and LS was an (unpaid) associate editor for BMC Systematic Reviews.

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Introduction

A 2017 investigation found that a considerable number of biomedical research studies supported by well-known funding organizations such as the National Institutes of Health (NIH), were published in so-called "predatory journals"[1]. Predatory journals are regarded as non-credible and are criticized for failing to provide typical or expected publishing services and their lack of transparent operations[2,3]. Such services include peer review, long term preservation of content, and indexing in scientific, bibliographic databases. Among predatory journals' many shortcomings, the failure to ensure permanent, future discoverability of research is a prominent feature threatening the integrity of science. Research that cannot be found by others cannot contribute to science, thus time, money, and resources are wasted[1,4]. Funders ought to be concerned that funded research may be published in journals that do not ensure discoverability of content ensuring it is available to contribute to future science. Benefits from investments in research are difficult to quantify[5]. One of the few ways for research funders to measure returns on investments is by tracking research outputs, including scholarly publications[6]. Predatory journals may limit the scientific return of funders' investments if their content cannot be reliably found.

Funders & Open Access

Most major funders of health research now mandate that funded research outputs be open access[7]. Such open access mandates typically require researchers to ensure that research (and sometimes data) is published in an open access journal or is deposited in a publicly accessible digital repository (regardless of whether the publication was published in an open access journal), or both. Some journals, called delayed-access journals, may impose an embargo period only after which an article is made publicly available or can be archived in a repository. Many funders' policies allow for such delays in open access to accommodate publishers' preferences.

Open access policies are one way for funders to direct funded researchers towards publishing in credible journals abiding by established open access tenets[8]:

1. Research is/should be freely available and accessible to anyone.
2. The copyright accompanying published work should be open, allowing for free use and re-use (i.e., allowing research to be freely built on/adapted with attribution).

To facilitate researcher adherence with funder open access policies, many biomedical journals offering open access have agreements with the PubMed Central (PMC) repository to automatically deposit their published content on authors' behalf[9]. Additionally, researchers funded by the NIH and 13 partner funding organizations in the USA can upload funder-supported publications to PMC from journals without PMC agreements[10]. Likewise, 29 funders from across Europe can submit funder-supported research to Europe PMC (which is mirrored in PMC)[11]. For some of these organizations, such as the NIH and Wellcome Trust,archiving in PMC or Europe PMC, respectively, is mandatory.

Predatory journals often market themselves as 'open access' and work to aggressively attract submissions[12,13]. Research in predatory journals may indeed be free to access – if it can be discovered. However, at best, predatory journals' identification through search engines is sparse and inconsistent, and these journals tend not to be indexed in scientifically-curated, bibliographic databases used by researchers[14–16]. Rather, predatory journal articles may appear haphazardly in search engines such as PubMed (since it includes author-uploaded articles from PMC)[17]. Additionally, we do not know whether content in predatory journals will be perpetually available if a journal ceases to operate. Content preservation is typically secured by publishers through service agreements with digital preservation providers (e.g. Lots of Copies Keep Stuff Safe, LOCKSS). For journals indexed in Medline, for example, this is a prerequisite of indexing[18]; PMC functions as a preservation service (i.e., has a remit to preserve content funded by public money)[19]. It is unknown whether predatory journals, not formally indexed in Medline, PMC, or other databases with similar requirements, have digital preservation arrangements.

Most researchers have a limited understanding of what open access means beyond making research free to read[20–23]. Free use and unrestricted re-use of research is a fundamental component of open access and licensing to permit this is a regular component of open access journals[24]. Journals running nefarious and deceptive publishing operations have likely benefited from or exploited this lack of awareness[25]. Indeed, few predatory journals mention licensing for articles or provide information on the use and re-use of published research[24]. Without explicit licensing for published articles, the legalities around distributing or building on research in predatory journals, for example, is uncertain. Whether researchers are deceived by predatory journals or are knowingly seeking easy and rapid publications in them (these journals tend to deliver quicker turnaround time than credible journals due to subpar or non-existent peer review[26,27]), they are likely breaching the open access policies set out by their funders.

In January 2017, the Bill & Melinda Gates Foundation implemented a policy mandating open access to research publications and data, without delay for all funded research[28]. In February 2017, they initiated a one-year partnership pilot with the American Association for the Advancement of Science (AAAS) to enable Gates-funded research to be published as open access in five AAAS journals, including *Science*[29]. The Gates-AAAS partnership seemed to inspire several other influential journals (i.e., *New England Journal of Medicine*, *Proceedings of the National Academy of Sciences*) to introduce policies ensuring permanent open access for Gates-funded research[30].

In January 2021, a number of international funders (including UK Research and Innovation, the Gates Foundation, Wellcome Trust, and the World Health Organization), led by Science Europe (a group representing funders across Europe), are set to deliver a radical change to the way that funded research is published via Plan S (coalition-s.org). Plan S will, in part, require research

funders to mandate open access to funded research through publication in an open access journal or on an open access platform; and require that publications be made available through an open access repository immediately upon publication. To support this, agreed funders will pay the cost of article publishing charges (APCs) (up to a yet unannounced limit) to journals that are immediately and wholly open access (sometimes referred to as 'gold' open access).

Whether health research funding bodies, prior to Plan S, provide funded researchers with guidance or support towards selecting publishing journals in line with their policies and which facilitate proper access to research, and whether they monitor such policies, is unknown. Previous studies confirm that many non-commercial health research funders' have policies requiring open access to completed research or results via publication or otherwise[31,32]. Yet none seem to have assessed whether funders provide any specific information to researchers to facilitate their choice of publishing journal. For public or charitable funders, providing such guidance or support may be one way of ensuring responsible stewardship of public or donor funds. The current work will establish a pre-Plan S baseline of health research funders' guidance and recommendations to researchers for selecting journals in which to publish funded research.

The aim of this research was to describe the policies and recommendations of major health research funding bodies regarding suitable publication venues for funded research.

Methods

We considered the public websites of 50 health funding bodies for statements, guidance, or policies specifically mentioning the publication of funded research. Detailed methods and rationale for this study are elaborated in an *a priori* study protocol (https://doi.org/10.17605/OSF.IO/J6CSK) and summarized below.

Data source

Global funding bodies with the largest documented health research expenditures were sampled from the curated Health Research Funder's list found at: www.healthresearchfunders.org[33]. The list was developed as part of an unfunded post-doctoral project by researchers in the Netherlands[33]. It was last updated in 2016; expenditure data are reported in 2013 US dollars (USD, accounting for inflation/deflation rates by country). A detailed account of the systematic process used to identify funders and obtain expenditure data is found here: http://www.healthresearchfunders.org/faq/. At the time of retrieval for this study (August 2017), 287 health research funding bodies from 30 countries were included on the list. The list distinguishes five categories of funders: [1] philanthropic funders (n=194), [2] public funders (n=77), [3] public funders who fund health research through Official Development Assistance (public ODA)[1] (n=8), [4] multilateral funders (funding across countries) (n=7), and [5] public-private partnerships (PPP) (n=1) (Table 1). While there are some inequities in its coverage (e.g. public funders were selected from only G20 countries; paucity of funders from low income countries), the list is likely the most comprehensive source of global health research funder expenditure information in existence (personal communication, Dr. Beverley Holmes, Michael Smith Foundation for Health Research) and has been used to construct samples in at least two other studies[32,34]. This study excludes commercial funders since their expenditure data are not publicly or readily available.

Sampling

To construct our sample, we sought up to 15 funders with the largest expenditures from each of the five funder categories from the list at www.healthresearchfunders.org, and aimed to include all listed lower income countries (n=4) if they were not otherwise represented in the sample. We included the latter group of funders in order to ensure representation from lower income countries, since researchers and journals from these countries have been disproportionately implicated in predatory publishing[24,35]. Working with the available number of funders in each category (Table 1), we ended up with 50 funders: 15 philanthropic, 15 public, eight public ODA, seven multilateral, one PPP, and four lower-middle income country funders.

In line with previous investigations into health research funder policies[32,36], we expected that guidance for funded researchers would be publicly available and easily obtained. For each included funder, one of us (LS) visited the website using the URL provided by www.healthresearchfunders.org, or if the URL was not working, found it through a Google search using the funder name. When a funder's website could not be located/did not work or when the funder was a duplicate, the next largest funder on the list was used. For each funder, we sought and downloaded the website section on policies for funded research in August-September 2017. If no specific policies were found, we searched the SHERPA (Securing a Hybrid Environment for Research Preservation and Access)/Juliet database (www.sherpa.ac.uk/juliet/index.php), which lists and links conditions for open access publication for some funders (though this is incomplete as it is reliant on voluntary contributions from funders and other organizations [e.g., libraries] tracking funder policies). If a funder's website did not mention funding health research (i.e., funded other scientific research) or if the funder did not specifically award grants for research, the funding body was excluded from the sample and replaced with the next largest funder (by expenditure), where possible. Reasons for exclusion are documented in Figure 1.

Data extraction

One assessor (LS) extracted information from the downloaded policy documents into an online form in Distiller SR, and a second assessor (KDC or MJP) verified the extracted data. Discrepancies were resolved by discussion. If additional documents were identified during extraction, we saved them and searched them for the desired data. The verification process led to clarifications in collected data or provided additional information.

[1]ODA is a term coined by the Development Assistance Committee of the Organisation for Economic Co-operation and Development (https://data.oecd.org/oda/net-oda.htm)

Table 1. Annual Expenditure across health research funders (in 2013 USD millions) by World Bank income level and type of funder.*

World Bank Income Level 2014	Type of Funder annual expenditure in 2013 USD millions (# of funders) [range]				
	Philanthropic	**Public**	**Public-ODA**	**Multilateral**	**PPP**
high income: non-OECD†	None listed	274.31(5)‡	None listed	None listed	None listed
high income: OECD	4995.25 (194)§	39847.47 (50)**	344.40 (8)	None listed	None listed
upper middle income	No data (1)	1540.87 (13)††	None listed	None listed	None listed
lower middle income	None listed	140.26 (4) ‡	None listed	None listed	None listed
low income	None listed	None listed	None listed	None listed	None listed
Income level not stated	None listed	6111.78 (5)	None listed	137.09 (7) **	455.36 (1)

*Created from data at healthresearchfunders.org.
† OECD: Organisation for Economic Co-operation and Development.
‡ Includes 3 funders with no expenditure data available.
§ Includes 11 funders with no expenditure data available.
** Includes 1 funder with no expenditure data available.
†† Includes 5 funders with no expenditure data available.

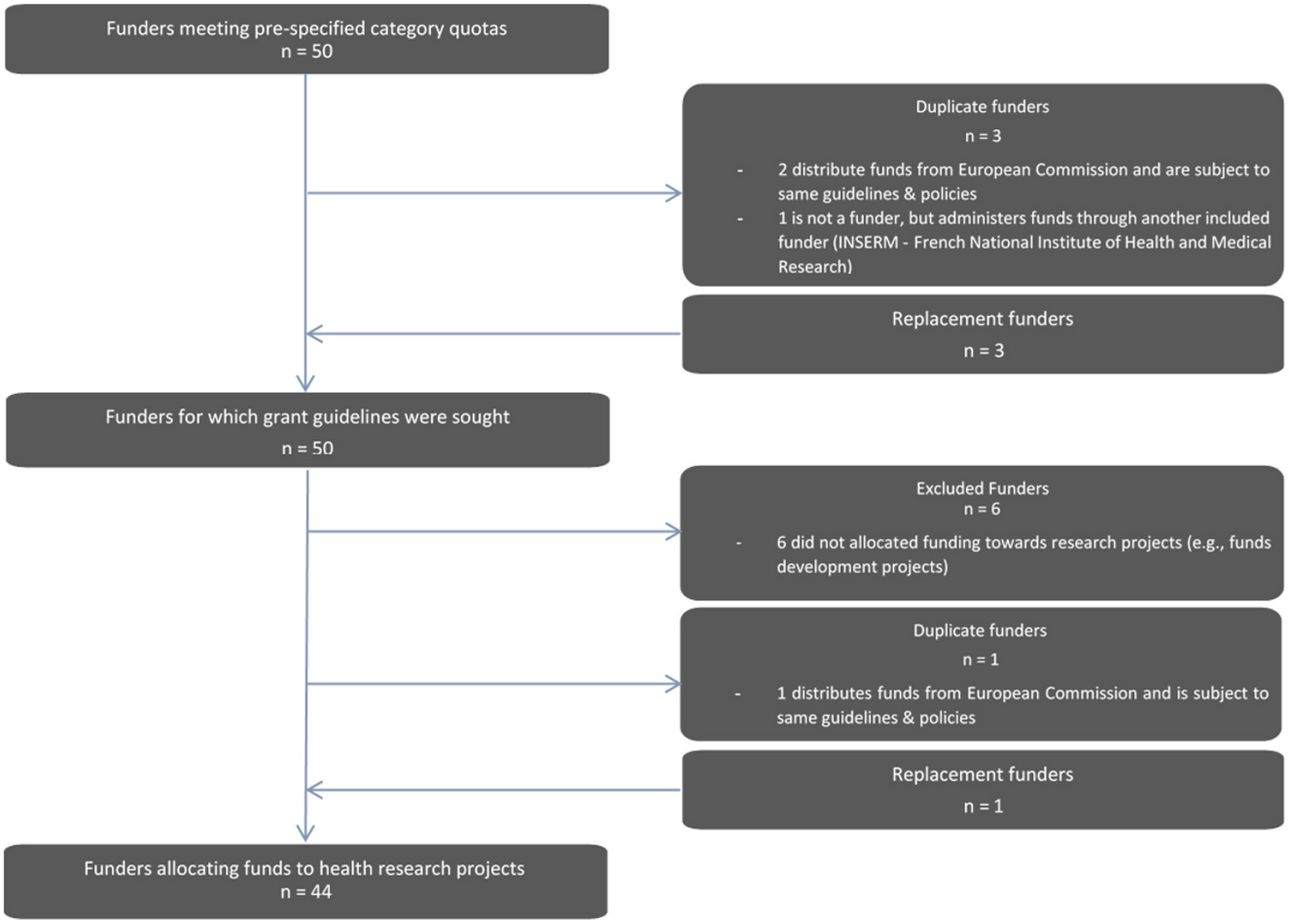

Figure 1. Flow diagram for selection of included funders.

The following information was assessed or extracted, as available:

- Any statement(s) about the dissemination of outputs from funded research
- Policy or recommendations about publication of funded research
- Policies or recommendations on research/data accessibility
- Policies or recommendations on journal quality, impact factor or other metric, ethical standards, and indexing of funded research;
- Whether/what information is provided to researchers about predatory or substandard journals, or about journal credibility
- Strength of any aforementioned policies/recommendations ('must', 'should', or 'suggested')
- For publication policies, whether adherence will be monitored
- For publication policies, whether consequences of non-adherence are listed

If non-English websites or documents were encountered and an English-language version was not available on the website, Google Translate was used to automatically translate the websites and documents. Google Translate has recently shown 85%-97% accuracy across nine languages for translating health research studies[37], including the languages encountered in this study (French and German).

Data analysis

We summarized data descriptively by calculating proportions for dichotomous data; the date of funder policies/recommendations were summarized as medians and interquartile range.

Protocol deviations

In the protocol for this study, we stated that we wanted to determine whether there were differences in the number of funders with policies/statements about journal quality and predatory publishing based on the income-level of the funder country or country being funded. However, as only four funders from lower-middle income countries and none from low income countries were on the list we sampled from, there were not enough funders to enable meaningful comparisons between higher income and lower income countries.

Results

For the 50 funding bodies originally identified using the described sampling technique, three allocated money from a funder (European Commission[2]) already in the sample and were replaced with the next organizations on the list. One of the replacement funders also allocated money from an included funder and was also replaced. Two funders funded non-health research and four funders did not list any research grants (and appeared to fund health development initiatives) and could not be evaluated for our purposes. Overall six funders were excluded and lacked replacements in the categories they belonged to. 44 funders remained in the sample for which grant policies and guidelines were sought (Figure 1). 35 funders are from high income countries, one from upper-middle income (China), three are from a lower-middle income country (India), and five are not classified by income level because they are multilateral (n=3) or fund across the European Union (EU) (n=2, Table 2).

38 of 44 funders (86%) had publicly available information for grantees about disseminating funded research outputs (Table 3). Of the six funders that did not have publicly available information, five are from high-income countries (US, Germany, France, UK) and one funds research in the EU through public-private partnership. Three are philanthropic organizations and two are public-ODA funders. Information about disseminating research was contained within "policies" for 29/38 (76%) funders, "recommendations" (suggestions and guidance) for 8/38 (21%) of funders, and as a "code of conduct" for one funder (Table 3). All but one policy/recommendation referred to funded research (including results) as the unit of dissemination (37/38, 97%). Over a third of policies/recommendations also specifically mentioned the dissemination of "data" (25/38, 66%). The median implementation date or date listed on collected documents was September 2014 (IQR: Apr 2012 to Apr 2016, n=35).

Open access and journal selection

36 of 38 policies/recommendations (95%) specifically referred to publication in a journal as one form of dissemination for completed research (Table 4). 31 of these (86%) mentioned that

Table 2. Description of funders (n=44).

Descriptor		
Type of funder, n(%)	Philanthropic	15 (34%)
	Public	18 (41%)
	Public ODA	7 (16%)
	Multilateral	3 (7%)
	Public Private Partnership	1 (2%)
Country Income Level, n(%)	High income	35 (80%)
	Upper-middle[i]	1 (2%)
	Lower-middle	3 (7%)
	Low income[ii]	0 (0%)[iv]
	N/A[iii]	5 (11%)
Annual expenditures (in million 2013 USD), mean (n)	High income	$1,113.191 (35)
	Upper-middle	$621.273 (1)
	Lower-middle	$140.261 (1)
	Low income[iv]	-
	N/A[iii]	$862.024 (5)

[i] China.
[ii] All funders from India.
[iii] Income-level not available since funders distributing funds across multiple countries (3 multilateral funders and 2 European Union funders).
[iv] No funders from "Low income" countries in sample.

[2]Any European Commission funding program that explicitly stated using the European Horizon 2020 guidelines for grantees were jointly represented as "European Commission". (Figure 1)

Table 3. Funder Policies on publishing.

		n(%)
Publicly available webpage or document(s) on funder website discussing dissemination of research outputs[a]		38 (86%)
Type of statement about research outputs[b,c]	Policy	29 (76%)
	Recommendation/ Guideline	8 (21%)
	Other	1 (3%)[d]
Dissemination pertains to specific research output[b]	Research	37 (97%)
	Data	25 (66%)
	Other materials[e]	14 (39%)
Date of effect[f] [median (IQR)]		Sept 2014 (Apr 2012-Apr 2016)

[a] Denominator = 44 funders with grant guidelines.
[b] Denominator = 38 funders with statements about research outputs.
[c] Policy: uses the words "policy", "must", "require"; Recommendation/ Guideline: uses the words "recommendation" "recommend", "suggest", "should", "guideline".
[d] Other - described as "Code of Conduct".
[e] Verbatim: activities of funded organizations; all research outputs, news releases; photos; any and all other published material referencing the research project or grant; code; research materials; protocols; research resources including, but are not limited to, the full range of tools that scientists and technicians use in the laboratory, such as cell lines, antibodies, reagents, animal models, growth factors, combinatorial chemistry, DNA libraries, clones and cloning tools (such as PCR), methods, laboratory equipment and machines; presentations; media interviews; and other professional activities; 'research tools'; metadata; bibliographic metadata; supplementary materials; other supporting artefacts, research resources/tools.
[f] Out of 35 funders listing this information. Date of implementation was used if available, otherwise, date of document or last update was used. When only year was given, January was used as default month; when a date range was given the most recent date was used.

Table 4. Funder position and information provided about journal publication of funded research (n=38).

		n (%)
Mentions journal publication of research outputs	Yes	36 (95%)
	Mandatory	0
	Suggested/encouraged	36
	Can't tell	0
	No (but sharing of research mentioned)	2 (5%)
Offers guidance on journal selection[1]	Yes	13 (36%)[2]
	No	23 (64%)
Mention of journals' or publishers' integrity or credibility.[1]	Yes	6 (17%)[3]
	No	30 (83%)
Journal practices or characteristics mentioned[1]	Open Access	31 (86%)
	Journal Impact Factor (JIF)	0
	Any measure/description of journal quality[4]	4 (11%)[5]
	Peer review	30 (83%)
	Any transparency or ethics standards	11 (31%)[6]
	Database indexing (excluding PMC)	0
	Other	2 (6%)[7]
	Nothing specific about journals mentioned	4 (11%)

[1] Denominator: 36 funders mentioning journal publication.
[2] See Table 5 for verbatim text of statements about journal selection.
[3] See Table 5 for verbatim text of statements about journal credibility.
[4] excluding JIF.
[5] 2 funders indicate journal should be "high quality, peer reviewed journal"; 1 funder indicates journal should be "quality peer-reviewed journal"; 1 funder indicates what a good journal is: "Good journals have guidelines for reviewers of manuscripts committing them to strict confidentiality/ to disclose conflicts of interest and promise to respond to submitted manuscripts within a specified, short time limit, and correspondingly set their reviewers short time limits for their comments."
[6] See Table 6 for transparency or ethics standards for publications.
[7] Other: 1 funder encourages publication in "primary scientific journals"; 1 funder states "models and mechanisms for publication and access to research must be both efficient and cost effective";.

research should be open access, either through journal publication (n=24, 77%) or through self-archiving the final report or accepted manuscript in a freely accessible repository (such as PMC) (n=30, 97%). One funder from India (Indian Council of Medical Research), one from France (Institut National de la Santé Et de la Recherche Médicale, INSERM), and three from the USA (US Department of Defense, Congressionally Directed Medical Research Program, and the American Cancer Society) did not mention open access in their policies about research dissemination.

13 of 36 (36%) policies recommending publication contained some guidance on how to select a journal and six (17%) listed features or requirements of publishers or journals for researchers to look for (Table 5). These six are described here. Only one funder policy (NIH) included a definition of a journal (i.e., either a publication listed in the journal section of the National Library of Medicine or one meeting stated criteria). And only one funder policy (Canadian International Development Research Council, IDRC) appeared to provide any information about 'questionable' journals in a guidance document entitled "Publishing in Open Access Journals". The document lists journal features to "look for" and to "be wary of" and mentions Beall's List[3] as a resource (Table 5). One policy (Deutsche Forschungsgemeinschaft/German Research Foundation, DFG) linked to Think, Check, Submit (www.thinkchecksubmit.org) – an initiative to facilitate researchers' assessment of the credentials of a journal – on a page supplementing their open access policy listing open access resources. Two funders distributing APC fees through the Charitable Open Access Fund (Cancer Research UK and Wellcome Trust) list the requirements of journals whose APCs are eligible for payment through the fund. The Bill and Melinda Gates Foundation provide researchers with a portal (called Chronos) through which

[3]Beall's List is an archived listing of potential predatory journals and publishers, as determined by librarian Jeffrey Beall between 2011 and 2017, https://web.archive.org/web/20170103170903/https://scholarlyoa.com/

Table 5. Funder statements on journal selection, requirements & credibility.

Funder	Journal Selection	Specific publisher/journal requirements or acceptability/credibility features	Name of webpage/source document
Bill & Melinda Gates Foundation	"Open access publishing is a non-negotiable term included in all grant agreements as of January 1, 2015. Please log into Chronos to search and find journals that offer open access options as required by the foundation's policy." "Our Open Access policy contains the following elements: 1. Publications Are Discoverable and Accessible Online. Publications will be deposited in a specified repository(s) with proper tagging of metadata. 2. Publication Will Be On "Open Access" Terms. All publications shall be published under the Creative Commons Attribution 4.0 Generic License (CC BY 4.0) or an equivalent license. This will permit all users of the publication to copy and redistribute the material in any medium or format and transform and build upon the material, including for any purpose (including commercial) without further permission or fees being required. 3. Foundation Will Pay Necessary Fees. The foundation would pay reasonable fees required by a publisher to effect publication on these terms. 4. Publications Will Be Accessible and Open Immediately. All publications shall be available immediately upon their publication, without any embargo period. An embargo period is the period during which the publisher will require a subscription or the payment of a fee to gain access to the publication. We are, however, providing a transition period of up to two years from the effective date of the policy (or until January 1, 2017). During the transition period, the foundation will allow publications in journals that provide up to a 12-month embargo period…"	"Chronos will list the most current information about which journals offer these [open access] options, i.e., the listing for Science will reflect the current agreement between the Gates Foundation and the American Association for the Advancement of Science (AAAS)."	Open Access Policy - Frequently Asked Questions
Bloodwise	"If the journal is not compliant with our open access policy, grant holders can request from Bloodwise that grant underspend is used to cover the cost with a justification for publishing in a non-compliant journal"/"Researchers can determine which publishers are compliant with this policy by referring to the SHERPA/FACT database and checking against the Wellcome Trust's policy, which has the same stipulations."	None stated	Project grants – guidance for applicants
British Heart Foundation	All of our Grantholders submitting manuscripts to journals should find out in advance whether the publisher supports open access and how they can comply with paragraph 2 above.	None stated	Open Access Policies
Cancer Research UK	"The journal you publish in must be published by a publisher who has agreed to the COAF/Wellcome Trust publisher requirements. Cancer Research UK and the Charity Open Access Fund (COAF) will only fund APCs where the publisher has agreed to the COAF/Wellcome Trust publisher requirements. These publisher requirements set out the open access services that publishers must agree to provide when they charge APCs for COAF-funded researchers. Most major publishers and many smaller publishers have signed up to these requirements. If you would like to check that the publisher of your chosen journal is compliant, search the SHERPA/FACT database here. Select the name of the relevant journal and Cancer Research UK as your funder – as long as the results show at least one 'tick' (|), the journal is compliant by that route."	"Publishers who want to provide open access publishing services for Wellcome and Charity Open Access Fund (COAF) grantholders through peer-reviewed journals based on article processing charges (APCs) must commit to providing a service that meets our requirements. Our open access policy (/funding/managing-grant/open-access-policy) states that when Wellcome funds are used to pay an APC, the article must be deposited, at the time of publication in PubMed Central (PMC). It will then be mirrored to Europe PMC. All deposited articles must be made available under the Creative Commons Attribution (CC-BY) Licence. COAF follows the same policy. Wellcome and COAF's open access policies and requirements are designed to maximise the availability and reuse of publications. We hope that publishers will continue to support us and our grantholders in this endeavour. We recognise that relationships in the publication process are not straightforward – we have grant-funding relationships with researchers, who then establish relationships with publishers. This can lead to confusion about what Wellcome and COAF expect from publishers. Our requirements clarify the service that publishers who receive Wellcome or COAF funds need to provide."	Open Access Policy/Publisher Requirements

Funder	Journal Selection	Specific publisher/journal requirements or acceptability/credibility features	Name of webpage/source document
Deutsche Forschungsgemeinschaft /German Research Foundation	"The approved funds are only for the publication of essays in original Open Access journals. The funds may only be spent provided that the following conditions are met:...The articles to be published appear in journals whose contributions are all accessible to users free of charge ("genuine open access journals") immediately after their publication on the Internet, and which apply the strict quality assurance procedures recognized in the relevant subject... The funds provided by the DFG may not be used to publish open essays in journals subject to subscription (according to the "Open Choice" model etc.) for Open Access."* "Guiding ideas for choosing appropriate means of publication: http://thinkchecksubmit.org"	"Recommendation 12: Scientific journals shall make it clear in their guidelines for authors that they are committed to best international practice with regard to the originality of submitted papers and the criteria for authorship."/ "all good scientific journals report when a manuscript has been received and when – usually following peer review – it has been accepted"	Further information on Open Access
German Federal Ministry of Education and Research (BMBF)	"Scientific articles from projects funded by the BMBF should either be published directly under an open access model or be put into a suitable document server after expiry of an embargo deadline. The researchers remain free in their choice, whether and in which journal they want to publish"	None stated	Press Release announcing Open Access Strategy
Howard Hughes Medical Institute	"HHMI strongly encourages all HHMI laboratory heads to publish their original, peer-reviewed research in journals that make publications freely available and downloadable on-line immediately after publication (i.e. open access journals). If a laboratory head chooses to publish an original, peer-reviewed research publication on which he or she is a major author in a journal that is not open access, the laboratory head is responsible for ensuring that the publication is freely available and downloadable on-line as soon as reasonably possible after publication, and in any event within twelve months of publication."	None stated	Public Access to Publications
Indian Department of Biotechnology (DBT)	"The DBT and DST recognize the right of researchers to publish their work in journals of their choice, because researchers are the best judges of where to publish their work. The DBT and DST expect that the recipients of funding will publish their research in high quality, peer-reviewed journals." AND "Results should be published in an appropriate form, usually as papers in refereed journals, with copies being made available through PubMed Central (PMC) and UK PubMed Central (UKPMC) as soon as possible and in any event within six months of the journal publisher's official date of final publication."	None stated	DBT and DST Open Access Policy
Indian Department of Science & Technology (DST)	*same as Indian Department of Biotechnology (DBT)*	None stated	DBT and DST Open Access Policy

Funder	Journal Selection	Specific publisher/journal requirements or acceptability/credibility features	Name of webpage/source document
IDRC/Global Affairs Canada	"Authors should carefully consider the quality standards of publications and ensure that appropriate peer review mechanisms are followed. The Directory of Open Access Journals, maintained by Infrastructure Services for Open Access (IS4OA), lists open access journals that have been reviewed for quality. Authors can also refer to the information guide Publishing in Open Access Journals, which lists journal quality indicators to evaluate potential publication outlets."	While most open access journals are peer-reviewed and high quality, there are a number of questionable journals, i.e. journals that do not subscribe to most or any of the practices of legitimate, academic journals. There is no single rule or test to indicate whether an open access journal is reputable. But here is what you should look for and what you should be wary of to avoid publishing in a questionable journal: Look for ... • Journal scope is well-defined and clearly stated • Journal is affiliated with or sponsored by an established scholarly society or academic institution • Editor, editorial board are recognized experts in the field • Articles are within the scope of the journal and meet the standards of the discipline • Any publishing fees or charges are easily found on the journal website and clearly explained • Rights for use and re-use of content at article level (e.g., Creative Commons CCBY licence) are clearly indicated • Articles have DOIs (Digital Object Identifier, e.g., doi:10.1111/j.1742-9544.2011.00054.x) • An ISSN (International Standard Serial Number e.g. 1234-5678) has been assigned • Publisher is a member of Open Access Scholarly Publishers Association (OASPA) • Journal is listed in the Directory of Open Access Journals (DOAJ) • Journal is included in established subject databases and/or indexes (e.g., Academic Search Com- plete, Medline, etc.) Be wary of ... • No journal scope statement or one that is vague • Website mimics other well-known publishers' site, or links or uses logos of recognisable entities although there is no actual connection • Journal title is very similar to title of a more established journal • Poorly maintained Web presence, including dead links, multiple spelling and grammatical mis- takes (on website and in articles) • No editor, editorial board, or editorial staff is listed, or they lack affiliation • Publisher is also the editor of the journal and/or editorial boards members serve on the board of multiple titles from the same publisher • Authors have several articles in the same issue • Publisher uses direct and unsolicited marketing (i.e., spamming) or advertising is obtrusive (to publish articles or serve on editorial board) • No information is provided about the publisher or location; either information is missing or does not match geographical area covered by the journal (e.g., "American Journal of ...." but published in Croatia) • Instructions to authors regarding peer review, copyright and/or fees (APCs), are not listed on web- site or are unclear • Publisher promises unusually rapid peer review and publication schedule Open Access • New (but self-proclaimed "leading") publisher with a large number of journals • Journal not listed in the Directory of Open Access Journals (DOAJ) • Claims to be indexed by Google and Google Scholar (or other search engines that crawl the Web) • Refers to bogus metrics meant to mimic Impact Factor (e.g., Journal Influence Factor, Global Impact Factor, etc.) • Publisher has a negative reputation (e.g., documented examples in Chronicle of Higher Education, list-servs, etc.) • Journal or publisher appears on Beall's List of Predatory Journals and Publishers Tools to find and evaluate open access journals: • Directory of Open Access Journals: http://doaj.org/ Online index of open access, peer-reviewed journals • Beall's List of Predatory Journals and Publishers: http://scholarlyoa.com/ List of potential, possible or probable questionable scholarly open access publishers and standalone journals • SHERPA/RoMEO: http://www.sherpa.ac.uk/romeo/ Online index of publisher copyright and self-archiving policies	Open Access Policy for IDRC-Funded Project Outputs/IDRC Publishing in Open Access Journals

Funder	Journal Selection	Specific publisher/journal requirements or acceptability/credibility features	Name of webpage/source document
National Health & Medical Research Council (Australia)	"NHMRC acknowledges that researchers take into account a wide range of factors in deciding on the best outlets for publications arising from their research. Such considerations include the status and reputation of a journal, book, publisher or conference, the peer review process of evaluating their research outputs, access by other stakeholders to their work, the likely impact of their work on users of research and the further dissemination and production of knowledge. Taking heed of these considerations, NHMRC wants to ensure the widest possible dissemination of the research supported by NHMRC funding, in the most effective manner and at the earliest opportunity.	None stated	NHMRC OA policy
National Institutes of Health	"Awardees must ensure that any publishing agreement allows the paper to be posted to PMC in accordance with the NIH Public Access Policy. NIH does not dictate the means by which awardees must do so, but does offer guidance in an FAQ on suggested wording for publishing agreements."	"If a publication is in the journal section of the NLM catalog, NIH considers it to be a journal. Search the journal section of NLM Catalog (http://www.ncbi.nlm.nih.gov/nlmcatalog/journals) for the journal by title, title abbreviation, or ISSN. Automatic suggestions will display as you type. If the publication is not on the list, NIH will consider it a journal for policy purposes if it meets all of the following criteria: Publication must meet the requirements for ISSN assignment; Publication content is issued over time under a common title; Publication is a collection of articles by different authors; Publication is intended to be published indefinitely; You may also submit the manuscript to NIHMS upon acceptance for publication for a determination."	National Institutes of Health Plan for Increasing Access to Scientific Publications and Digital Scientific Data from NIH Funded Scientific Research/NIH FAQ on Public Access Policy
Wellcome Trust	"We expect Wellcome-funded researchers to select publishing routes that ensure the work is available immediately on publication in its final published form, wherever such options exist for their publisher of choice and are compliant with our policy." "The [Charitable Open Access Fund] fund can only be used for APCs where the publisher has agreed to our publishing requirements." "Check that your journal of choice has a publishing policy compliant with our grant conditions. Wellcome-funded authors can use the SHERPA Funders' and Authors' Compliance Tool (http://www.sherpa.ac.uk/fact/) (SHERPA FACT) to check this."	*Same as Cancer Research UK*	Open Access Policy/Publisher Requirements

* "Open Choice" is a term used by the publisher *Springer* to refer to hybrid journals.

to submit manuscripts directly to pre-selected journals whose standards are in line with their requirements.

The policies of at least three funders (German Federal Ministry of Education and Research Indian [BMBF], Indian Department of Biotechnology [DBT], Indian Department of Science & Technology [DST]) include a statement that further to making research freely accessible, researchers' choice of journal was unrestricted.

Other journal characteristics mentioned by funders

Most funders mentioned that funded research should be peer reviewed or published in a peer reviewed journal (Table 4). Four funders made non-specific reference to selecting a "good" or "quality" journal in relation to publication of funded research; none mentioned the journal impact factor. Eight funders made statements about publication transparency or ethics. For instance, one funder discussed reproducibility in published research, three mentioned adherence to reporting guidelines, and at least six asked that metadata accompany published articles (Table 6).

Adherence to policies/recommendations

Of 38 policies/recommendations providing information about disseminating research outputs, only nine (24%) stated that they monitor adherence to either a policy (n=7) or recommendation (n=2); two philanthropic funders (Wellcome Trust and Bill & Melinda Gates Foundation) specified that they would evaluate publications of funded research reported to them to ensure they are published in journals meeting the funder's outlined publishing requirements (Table 7). No monitoring or adherence data appears to be publicly available. Only five (13%) funders with policies or recommendations about journal publication indicated that there would be consequences for non-adherence. And only two of those (Wellcome Trust and NIH) stated that they would withhold or suspend payments if articles are not made open access.

Discussion

Most health research funders appear to have active policies about the dissemination of funded research, typically in the form of policies about open access which often include statements about journal publication. Few policies provide guidance on how to select a journal, list features of journals meeting funder requirements, or about the credibility of publishing outlets. Only one health research funding organization (IDRC) made specific reference to the "questionable journals" at the time of data collection (August-September 2017). Additionally, few policies describe whether funded outputs are monitored for compliance with funders' dissemination policies, and few describe any consequences for researchers' non-adherence to their policies. Information is not available on whether the NIH or Wellcome Trust, both of whom promise to withhold or suspend grant funds for breaching their open access policies, have actually ever done so[7].

For many of the funders in our sample, information to guide publication of research was found across multiple documents and not always within the main open access policy statements/documents. For example, the only funder to provide guidance about predatory journals (IDRC) did so in a PDF (entitled "Publishing in Open Access Journals") that was linked to from their main open access policy. The policy itself did not flag that the document contained information about predatory/questionable/non-credible journals. This non-obvious placement of guidance or expectations around adherence to their funder policies relies on researchers' curiosity or knowledge that important information may be located outside of the main policy webpages or documents. If funders wish to provide guidance about journal credibility and predatory publishing, they may reach more researchers (and increase the likelihood of them reading it) by including such information within a single, main policy document aimed at funded researchers.

Comparison to other research

At least four previous studies examining health research funder policies on clinical trial transparency have collected information on funder's recommendations for disseminating research.

Two studies using similar methods evaluated trial transparency policies (i.e., those related to trial registration, access to summary results, individual data availability) for non-commercial health research funders globally (n=18)[32] and in the USA (n=9)[34]. After accounting for three common funders across studies, 21 of 24 (87.5%) funders (16 of which are represented in our study) either required or supported publication or registration of trial results (neither study or their available data distinguished between publication or registration). This is in line with our findings in which 86% (38 of 44) funders had such policies/recommendations.

A third study, published in 2017 which examined research waste-reducing policies of 11 non-commercial funders (six of which are represented in our study) reported six to be explicit in requiring publication of full reports of funded research[31]. In comparison, 36 of 38 policies/recommendations (95%) in our study referred to journal publication as one form of dissemination for completed research but did not indicate that it was mandatory. There may be differences in how authors of that study and interpreted language in documents or policies. The names of the six funders 'requiring' publication in that study were not obvious in either the publication or available data, so we are unable to investigate this further.

A study published in 2008 examined 73 UK and international non-commercial health research funders' guidance for reporting funded clinical trials[38]. 49 funders (67%) explicitly stated that trials could or should be published. Of the three funders appearing in the 2008 sample and ours, all have maintained recommending (but not requiring) the publication of trial results. Whether funders provided any guidance on selecting a journal to publish in was not collected in the study.

No previous studies appear to have investigated whether health research funders' provide guidance to help funded researchers select a journal for publication. Our study appears to be the most comprehensive investigation on this matter. This is surprising since our findings suggest that funders in our sample regard publication as the primary means of

Table 6. Transparency tools/activities mentioned by funders.

Funder	Additional publication transparency actions/initiatives mentioned	Source
Bill & Melinda Gates Foundation	"Publications Are Discoverable and Accessible Online: Publications will be deposited in a specified repository(s) with proper tagging of metadata."	Open Access Policies
Bloodwise (formerly Leukaemia & Lymphoma Research)	"Grant holders should make use of the ARRIVE guidelines when designing their experiments, and ensure that they report in vivo studies in accordance with the ARRIVE guidelines as far as possible."	Project Grants Guidance
Deutsche Forschungsgemeinschaft / German Research Foundation	Recommendation 7: Safeguarding and Storing of Primary Data. "Experiments and numerical calculations can only be repeated if all important steps are reproducible. For this purpose, they must be recorded. Every publication based on experiments or numerical simulations includes an obligatory chapter on "materials and methods" summing up these records in such a way that the work may be reproduced in another laboratory."	Safeguarding Good Scientific Practice
European Commission	"To be able to easily find the deposited publication, beneficiaries must also ensure open access – via the repository – to the bibliographic metadata that identify the deposited publication. This metadata must include a persistent identifier (such as the Digital Object Identifier, DOI) in order to allow easy and persistent referencing."	European Research Council (ERC) Guidelines on Implementation of Open Access to Scientific Publications and Research Data
Indian Council of Medical Research	Researcher's Relations with the Media and Publication Practices: "The term 'misconduct in research' means fabrication, falsification, plagiarism, selective omission of data and claiming that some data are missing, ignoring outliers without declaring it, not reporting data on side effects/ adverse reactions in a clinical trial, publication of post-hoc analysis without declaring it, gift authorship, not citing others' work, not disclosing conflict of interest, redundant publication, and failure to adequately review existing research. The Commission on Research Integrity in US created by US Congress addresses the scientific, ethical, social and legal issues involving scientific misconduct in research. Consolidated standards of reporting trials (CONSORT) guidelines have been prescribed for publishing results of clinical research especially RCTs (Randomised Controlled Trials) and are available at http://www.consortstatement.org.	Ethical Guidelines for Biomedical Research on Human Participants
Institut Pasteur	"To be able to easily find the deposited publication, beneficiaries must also ensure open access – via the repository – to the bibliographic metadata that identify the deposited publication. This metadata must include a persistent identifier (such as the Digital Object Identifier, DOI) in order to allow easy and persistent referencing."	European Research Council (ERC) Guidelines on Implementation of Open Access to Scientific Publications and Research Data
Medical Research Council (UK Research and Innovation since 2018)	G.8. Reporting Guidelines: "Agreed standards for reporting the outcomes of research in specific areas have been developed and should be observed. Standards endorsed and supported by the MRC include the CONSORT Statement (CONsolidated Standards of Reporting Trials)[46] and the ARRIVE guidelines (Animal Research: Reporting in-vivo experiments)[47]."	MRC ethics series. Good research practice: Principles and guidelines
NIH	5.a. Access & Discoverability: Meta Data. "Ensure full public access to publications' metadata without charge upon first publication in a data format that ensures interoperability with current and future search technology. Where possible, the metadata should provide a link to the location where the full text and associated supplemental materials will be made available after the embargo period; Ensure that attribution to authors, journals, and original publishers is maintained (OSTP memo, elements 3c, 3e)"	Plan for Increasing Access to Scientific Publications and Digital Scientific Data from NIH Funded Scientific Research
U.S. Agency for International Development	"Metadata [from a research dataset or publication] should be made accessible as soon as possible after final acceptance of a paper and appropriate review, even if the full text is subject to an embargo period."	Public Access Plan
World Bank	"Requires electronic copies of complete, final manuscripts, as defined above, as well as the associated metadata, to be deposited in the Open Knowledge Repository"	World Bank Open Access Policy for Formal Publications
World Health Organization	Summary of the open-access policy options and requirements: "Publisher deposits XML version of the article and metadata in PubMed Central, which automatically appear in Europe PubMed Central"	WHO open-access policy: Frequently asked questions for recipients of WHO funding

Table 7. Monitoring and consequences.

Funder Name	Adherence-monitoring strategy	Consequences for non-adherence
American Heart Association	(From OA policy) "In situations where the AHA or members of the research community feel that AHA-funded researchers are not sharing data in a manner consistent with our policy, you may be asked by the AHA to demonstrate your compliance."	"If you cannot do so [demonstrate compliance with OA policy], this may affect future funding."
Bill & Melinda Gates	(From FAQ about OA Policy) "The foundation checks and tracks compliancy through Chronos, a new service to help you manage the process of publishing under the policy's terms."	*None stated/identified*
Canadian Institutes for Health Research	*Nothing stated/identified*	*not specific to journal publication - but have consequences for breaches in policy, including breaches around dissemination of research*
Centers for Disease Control and Prevention	(From...) " Supervisors of publishing authors are responsible for ensuring compliance with the CDC Public Access Policy."	*None stated/identified*
Institut Pasteur	(From OA intentions) "The deposit is checked by the CeRIS library's Hal team, in particular when it comes to the rights of authors on their files and their affiliations to a lab and and institution."	*None stated/identified*
JRDF	*Nothing stated/identified*	(From Award Terms and Conditions) *not specific to publication* "JDRF may place the PI and/or his/her Grantee Institution on administrative probation if ...the Grantee Institution is non-compliant as outlined in this document. JDRF administrative probation may include, but is not limited to, the following actions: 1. Withholding of all payments for the grant/project in question 2. Changing to a payment reimbursement schedule 3. Withholding of all JDRF payments for the PI, for any JDRF grant 4. Withholding of all JDRF payments for the Grantee Institution, for any JDRF grant 5. Any combination of the above"
National Institutes of Health	(NIH Public Access Policy) "Compliance with this Policy remains a statutory requirement and a term and condition of the grant award and cooperative agreement, in accordance with the NIH Grants Policy Statement."	(NIH Public Access Policy - FAQ) "A grantee's failure to comply with the terms and conditions of award may cause NIH to take one or more enforcement actions, depending on the severity and duration of the non-compliance. NIH will undertake any such action in accordance with applicable statutes, regulations, and policies. NIH generally will afford the grantee an opportunity to correct the deficiencies before taking enforcement action unless public health or welfare concerns require immediate action. However, even if a grantee is taking corrective action, NIH may take proactive action to protect the Federal government's interests, including placing special conditions on awards or precluding the grantee from obtaining future awards for a specified period, or may take action designed to prevent future non-compliance, such as closer monitoring. See Enforcement Actions in the NIH Grants Policy Statement (10/12).."
Pan American Health Organisation	"Research commitments shall be reflected in institutional policies and program budgeting and planning, implementation, monitoring, and evaluation; human resource management; and knowledge management."	*None stated/identified*

Funder Name	Adherence-monitoring strategy	Consequences for non-adherence
UK Department for International Development	(From DFID Research Open and Enhanced Access Policy) "As part of its monitoring and evaluation framework, DFID Research and Evidence Division (RED) collects data on the extent to which researchers fulfil the requirements and recommendations of this policy. RED researchers are required to report open access activity, usually during the annual review."	*None stated/identified*
US Agency for International Development	(From Public Access Plan) "Potential future monitoring plans are suggested: "Further criteria/metrics for compliance and evaluation will be developed through consultations with M/OAA/P, GC, and other USAID Operating Units. This may include: A) requesting offerors to submit within their proposals a list of USAID-funded peer-reviewed publications (and the corresponding DEC-issued unique identifier number for publication) that resulted from their prior USAID awards when deemed appropriate by the CO; B) importing the metadata and links to the authors' manuscript or the publically available version of record of publications that resulted from USAID support, but were published after completion of the award in partnership with third-party reference services such as CHORUS and FundRef; and C) including compliance with open data and public access requirements of awards as a measure of past performance."	*None stated/identified*
Wellcome Trust	(From Complying with our OA policy) "We actively monitor research papers authored by our funded researchers to ensure they comply with our policy. This includes the review of publications listed in ongoing grant reporting and in end of grant reports. In addition, Wellcome-funded research papers detailed in applications submitted to us are reviewed to ensure compliance."	(From Complying with our OA policy) "When Wellcome-funded researchers do not comply with our open access policy, we will apply these sanctions: Applicants will be required to ensure that all their Wellcome-funded original research papers resulting from current or previous grants are compliant before we issue formal notification of any funding renewals or new grants. Where non-compliant research papers, book chapters and scholarly monographs are identified in an end of grant report, we will withhold the final 10 per cent of the total grant budget until all outputs comply. See our 10 per cent retention policy."

disseminating funded research. Further, studies show that researchers view journal publication as the primary way of disseminating research[39,40].

Strengths and limitations

This study is the first to examine the information funders provide researchers about selecting a journal in which to publish funded research. All funders in our sample that mention journal publication or provide guidance on selecting journals, do so within their open access policies. In a time where the scholarly publishing landscape has been infiltrated and confused by predatory journals, inadvertently resulting in some researchers trying to achieve open access to publish in predatory journals[41], funders can play a critical role in steering researchers in the right direction. Funders can be specific and explicit with regards to which journal features researchers should look for in order to select one that meets their open access requirements.

This study is an essential benchmark by which to monitor how major health research funders are performing pre and post Plan S implementation (planned for January 2021, at the time of writing). Data collection occurred in August & September 2017, prior to the September 2018 announcement of Plan S. So far, 24 funders have committed to implementing Plan S, five of which were considered in this research (European Commission, Gates Foundation, MRC/UK Research and Innovation, Wellcome Trust, and the World Health Organization). Two of these, the Wellcome Trust and Gates Foundation, provided guidance (in the form of tools) to facilitate selecting a journal in line with their open access policies at the time of sampling. At least one funder (Wellcome Trust) has made changes to their open access policies in anticipation of Plan S[42].

Our study relied on publicly available information about funder expectations of funded research and was abstracted by a single person with verification by a second (i.e., not two independent people). Six funders in our sample did not provide any relevant public information. We did not seek verification on policies from funders since data collection took place at a time when the publishing activities, particularly open access, was (and still is) rapidly changing, somewhat in response to the rise of predatory journals[41,43]. We are aware that the NIH issued a notice on their Public Access Policy in November 2017 (outside of our sampling and data collection period) with recommendations to publish funded research in journals with 'credible practices'[44]. The focus of this research is limited to health research funders. We have not accounted for or evaluated other potential scientific publishing gatekeepers such as academic institutions, governments, or companies carrying out scholarly research, despite the important role they can play[45].

Implications and recommendations for funders

Explicit funder policies on publication expectations. Selecting a journal in which to publish research is not a straightforward undertaking[46], particularly since the emergence of predatory journals. For funders looking to make their expectations around publishing funded research more explicit and more transparent, we propose several recommendations on how this might be achieved in Box 1, based on findings of this research and on

Box 1. Recommendations for providing explicit/ transparent guidance on journal selection in health research funders' open access policies

1. Use precise wording to describe your agency's expectations that funded research be published
   - Indicate whether researchers are expected to publish their research (e.g. use of "must" vs "should")
   - indicate whether open access publication is one of several options for meeting the agency's open access requirements.
2. Provide a definition of a journal that is suitable to your agency
   - Decide what essential features a publishing entity should and should not have in order to be considered a suitable place for publication.
   - Consider referring to/including the Committee on Publication Ethics (COPE) list of Core Practices all journals and publishers should follow: https://publicationethics.org/core-practices
   - The NIH definition of a journal is[47]:
     - Publication meets the requirements for ISSN (International Standard Serial Number) assignment;
     - Publication content is issued over time under a common title;
       - Publication is a collection of articles by different authors;
       - Publication is intended to be published indefinitely.
3. Indicate your agency's requirements for access and discoverability of published articles
   - Distinguish between free vs open access:
     - Published articles are free to access; AND additionally, for open access,
     - Licensing for published articles permit reuse and building on (typically through a Creative Commons Attribution License, CC BY).
   - Ensure that published research can be accessed in perpetuity
     - Researchers can determine whether the publishing journal has a permanent archival arrangement in place either through automatic deposition to PMC (https://www.ncbi.nlm.nih.gov/pmc/journals/), or to another archive (via the Keepers Registry: https://keepers.issn.org/keepers-registry)[xxv]
     - PMC-partnered funders can require that researchers upload published research directly to PMC
   - Journal provides unique permanent identifiers (e.g. digital object identifier [DOI]) (can check if journal/ publisher is registered with CrossRef: https://www.crossref.org/06members/51depositor.html)
4. Be clear about your agency's support for article processing charges arising from publication of funded research
   - Indicate how much money is available each open access publication (e.g. maximum APC amount)

- Indicate who will receive APC payment from the funder – the author (institution) or the journal
- Indicate when funding will be distributed to support article processing charges
- Indicate whether there are any conditions on distribution of APC funds

5. Indicate whether your agency requires archiving in a repository alongside publication
   - Indicate whether the publication, data, or both, are expected to be deposited in a repository
   - Indicate when deposition is expected to occur (i.e., immediately or within a specified time frame)
   - Indicate whether you have a dedicated repository for research publications (e.g., PMC for NIH-funded research), and if not, suggest one or more repositories that are considered acceptable by your agency
   - Be clear that it is the authors' responsibility to ensure publications are deposited in a repository
   - Provide instructions/link to resources on how to deposit research in the suggested repository.
6. Indicate how your agency will monitor that funded research is published in appropriate journals, in line with agency recommendations/mandates
   - For ease of monitoring, Provide instructions for researchers about where and how to include the funding agency name and grant number in published articles (guidance here: http://www.rin.ac.uk/system/files/attachments/Acknowledgement-funders-guidance.pdf)
   - Provide instructions on if, how, and when to submit publications of funded research to the funding agency, or state how publications will be monitored otherwise
   - Provide specific actions/consequences that the agency will carry out when funded research is published in a journal that does not meet agency requirements

[xxv]provides global monitoring of archiving arrangements for electronic journals.

the expertise of authors. Providing specific information about journal considerations in funders' policies to funded researchers may facilitate more thoughtful and responsible selection of journals. Several recommendations in Box 1 pertain to the explicitness of article/journal considerations mentioned in Plan S (e.g., persistent identifiers for publications; long-term preservation/archiving; article-level metadata). All health research funders may wish to consider making aspects of their policies that pertain to publishing more explicit, whether or not they intend to implement Plan S.

The NIH is the only funder in our sample to clearly describe what it considers a journal – either those listed in the journal section of the National Library of Medicine (NLM) (https://www.ncbi.nlm.nih.gov/nlmcatalog/journals) or those meeting a comprehensive set of criteria[47]: (1) meets the requirements for ISSN (International Standard Serial Number) assignment; (2) content is issued over time under a common title; (3) is a collection of articles by different authors; and (4) is intended to be published indefinitely. All but the final criterion are straightforward to judge; presumably it is meant to distinguish a journal from a book or a monograph however NIH or NLM do not provide guidance on how to judge this criterion. However, whether journals intend to publish indefinitely can be predicted or otherwise determined has not been described. A more meaningful criterion for distinguishing journals from non-journals may be whether the publishing entity has archival arrangements in place (e.g., with LOCKSS, Portico, PubMed Central) to ensure perpetual access to content in the event a journal ceases to operate. Since preserving publisher content may have associated costs[48], predatory or non-credible journals (which have been described as "primarily fee-collecting operations"[49]) are potentially unlikely to seek this service.

We surprised that the three funders from India in our sample (Indian Council for Medical Research, DBT, and DST) did not mention journal credibility or predatory journals, and further, that a common policy for two Indian funders (DST and DBT), dated December 2014, recognizes "the right of researchers to publish their work in journals of their choice, because researchers are the best judges of where to publish their work". Since at least 2016, there has been an ongoing national initiative combat predatory journals and to support researchers in their choice of journals across higher education institutes in India. The main product of this work has been a list of approved journals in which academic researchers are permitted to publish in as well as standard templates for researchers when communicating with journals[50]. The University Grants Commission (UGC), the regulator and funder of high education, has been leading the initiative. It is uncertain whether the country's largest health research funders are on board due to their lack of guidance in this space. A coordinated approach by a range of stakeholder groups[45], which includes funders (who have innate authority to implement mandates about publishing), may facilitate improved publication decisions by researchers. Importantly, however, UGC's list of approved journals has been plagued with numerous credibility concerns in its short existence[51,52]. Explicit recommendations from India's funders regarding credible and non-credible features of journals in which to publish may be warranted in the absence of a trusted and comprehensive list.

Facilitating and monitoring adherence to funder policies. Funders are well-positioned to provide researchers with resources and tools to help ensure that results from funded research are published in credible and discoverable journals, in line with their policies. Several organizations in our sample consistently offer more information about potential publishing routes and tools to facilitate adherence to their policies. We provide a list of tools to facilitate the development of funder policies on research outputs, adherence to such policies, and monitoring of policy adherence (Table 8).

Monitoring researchers' adherence to their policies may help funders understand the extent to which researcher's publishing

Table 8. Resources and tools that funders can use to support development of, adherence to, and monitoring of open access publishing policies.

Resource/Tool	URL	Origin	Description	Relevance & Implementation	Limitations
CHORUS	https://www.chorusaccess.org/	Association of American Publishers	A service that utilizes metadata from CrossRef Funder Registry and partner publishers to monitor the # of published articles and % that are freely accessible; prompts free article access if required by funder policies; ensures digital preservation.	FACILITATING ADHERENCE & MONITORING: Encourage researchers to include funder name and grant number in published articles. Ensure funder information is registered and correct in CrossRef Funding Registry.	Fee-based Only able to facilitate open access & preservation for publisher partners (paid service).
Chronos	https://chronos-oa.com/	The Bill & Melinda Gates Foundation	A service facilitating funders' management and tracking of the publication process for funded research outputs, through which pay APCs, and by which to manage subsequent archiving. Automatically collects information on where research was published, whether, when, and in which repositories published research and data were deposited, and the type of license research was published under.	FACILITATE ADHERNCE: Require that researchers use Chronos to submit any funder-supported research for publication; pay APCs directly to publishers instead of distributing as grant funding. MONITOR ADHERENCE: Use to monitor # of open access publications. Use as grant reporting tool to alleviate researchers of administrative responsibility.	Fee-based Only tracks publications submitted through Chronos.
CrossRef Funder Registry[xxvi]	https://search.crossref.org/funding	CrossRef	Tracks any published articles with a digital object identifier (DOI) issued by Crossref (main DOI registration organization) and for which funder metadata is available	MONITOR ADHERENCE: Ensure funder information is registered and correct in the Registry; use to search for publications and other research outputs with DOIs funded by a specific grant or by a funder overall.	No distinction between freely available vs. subscription content. Only able to track articles for which publishers have registered DOIs and funding metadata with Crossref (paid service). Dependent on authors reporting funding information during the submission process or on publishers extracting from article.
HowOpenIsIt? Guide to Research Funder Policies	http://www.orfg.org/policy-development-guide/	Open Research Funders Group; SPARC	Freely available framework for designing funders' open access policies. Provides policy examples along a spectrum of openness for five aspects of research outputs: article access, data and code access, reuse, costs, and compliance.	POLICY DEVELOPMENT: Use to facilitate design of a policy that includes recommendations on one or more aspects of openness of research outputs, that are feasible/desired.	None

Resource/Tool	URL	Origin	Description	Relevance & Implementation	Limitations
OpenAire	https://monitor.openaire.eu/	European Commission/ Horizon 2020	Uses metadata provided by a funder (i.e., grant number) to search for funded research outputs deposited in digital archives/repositories.	MONITOR ADHERENCE: Use to collect data on research outputs (including publications) that are available in repositories.	Only sees freely available outputs. Dependent on researchers including grant numbers within research outputs deposited in repositories. Relies on repositories being compliant/ providing necessary metadata.
PubMed Central (PMC)	https://www.ncbi.nlm.nih.gov/pmc	NIH	The US National Library of Medicine's (NLM) repository of freely available, full-text, published biomedical and life sciences articles; Dedicated repository for published NIH-funded research and for select other US and international funders. Publications can be deposited by journals with agreements with PMC or by researchers reporting NIH (or other agreed funder-) supported research.	FACILITATE ADHERNCE: Take appropriate steps to partner with PMC, Europe PMC, or the Health Research Alliance (NLM partner): https://www.ncbi.nlm.nih.gov/pmc/about/public-access/ . Require that all publications from funded research are deposited in PMC via a publishing journal or by authors.	Relies on journals agreeing to deposit to PMC or on authors to deposit published research for journals without PMC agreements.
SHERPA/FACT (Funder & Author Compliance Tool)	http://sherpa.ac.uk/fact/	Jisc; Wellcome Trust; Research Councils UK	Free online tool for researchers funded by the Wellcome Trust and members of Research Councils UK to check whether their intended journal meets funder open access requirements.	FACILITATE ADHERNCE: Request inclusion to be listed in FACT from Jisc. Direct funded researchers to use FACT to select a journal in which to publish in.	Relies on authors to use. Restricted to searching journals for which open access policies that have been collected
Think, Check, Submit	https://thinkchecksubmit.org	Publishing community led (collaboration among many publishing professionals/ organizations)	Freely available checklist to facilitate researchers in selecting a relevant and trustworthy journal in which to submit their research for publication consideration	FACILITATE ADHERNCE: Encourage authors to use checklist to facilitate selection of credible journal.	Relies on authors to read/understand/use Uncertain development process and validity of checklist items.

[xxvi] Previously known as FundRef (until Nov 2015).

practices are guided by their policies[53]. Informing researchers that their adherence to open access policies is being monitored may facilitate better awareness of such policies and potentially increase adherence to them[54]. A 2018 study examining the accessibility of research supported by 12 research funding agencies across North America and Europe with open access policies, found that 62% of almost 1.3 million articles over nine years were freely available[7]. In 2016, 90% of published research supported by the NIH and Wellcome Trust was free to access (via journal, repository, or both)[7]. Both agencies mandate the deposit of published research by publishing journals or funded authors into dedicated repositories (PMC for NIH; PMC Europe for Wellcome Trust). The remaining 10 funders in the sample did not mandate depositing in a repository alongside publication and had lower rates of freely accessible articles. For example, for the Canadian Institutes of Health Research (CIHR) only 55% of published research was freely accessible in 2016, even though the funder had a dedicated repository (PMC Canada) until 2018 (it closed due to low usage and high upkeep costs)[55]. The study's authors conclude that funders with low compliance rates used less enforcement and had less infrastructure to support compliance with their open access mandates[7].

Areas of future research

An important area of future study is whether researchers are being funded on the basis of grant applications that include research published in predatory journals – or in journals that may not be indexed in trusted databases. Predatory journals have made their way into consideration (via CVs submitted by researchers or through institution-initiated database searches) into applications for academic career advancement[56–58]. Some have called for such publications to either be discounted from consideration or for researchers who submit them for consideration to be prevented from career advancement overall[59,60]. It is unknown whether researchers are including publications in predatory journals as part of their funding applications. This should be evaluated. If they are, funders may wish to consider whether this is an important consideration for awarding funding.

Conclusion

Most large health research funders mandate open access to funded research outputs, typically by way of open access journal publication and by deposition of published research in digital repositories. Few funders provide guidance on what constitutes a journal (or an open access journal) or are checking to ensure that published research that they have funded is indeed meeting specified requirements about how research should be shared. Health research funding organizations have an obligation to support researchers in meeting their mandates so that research can, as intended, contribute to the broader evidence base. The publishing community needs to provide guidance to funders and researchers on universally acceptable and transparent standards for journal operations. Many solutions to improve policies, facilitate adherence, monitor compliance and work with other funders on large-scale improvements exist and should be implemented.

Journals that fail to make research discoverable breach the basic trust that researchers and their funders have in the current publishing system. Most funded researchers publish their work under the basic assumption that their journal or publisher is following best practices to ensure future use[61]. Bodies funding health research have a responsibility to protect their investments and even more importantly, to ensure that funded research is not wasted by being published in non-credible and non-discoverable sources.

Data availability

Underlying data

Open Science Framework: Audit of health research funder policies and recommendations on journal publication of research: Extracted Data, https://doi.org/10.17605/OSF.IO/YUDP4[62].

This project contains the following underlying data:

- Funders Data analysis data - clean 2020Apr21.dta

Extended data

Open Science Framework: Audit of health research funder policies and recommendations on journal publication of research: Study Forms, https://doi.org/10.17605/OSF.IO/FSUQ2[63]

This project contains the following extended data:

- Level 1 - Searching funder websites form 2017Nov23.pdf
- Level 2 - Data extraction form 2017Nov23.pdf

Open Science Framework: Audit of health research funder policies and recommendations on journal publication of research: Protocol, https://doi.org/10.17605/OSF.IO/J6CSK[64]

Registration of overarching OSF project: https://doi.org/10.17605/OSF.IO/Z59U6[65].

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Author contributions

The study was conceived of by LS, JG, and DM. LS drafted the initial protocol, with approval from the study team. LS managed the research project. LS, KDC, and MJP carried out the research. LS cleaned and analysed the data, prepared tables and figures, and drafted the manuscript. All authors provided feedback and gave their approval prior to submission.

#	Role	Author(s)	Definition
1	Conceptualization	LS, DM, JG	Ideas; formulation or evolution of overarching research goals and aims.
2	Data curation	LS	Management activities to annotate (produce metadata), scrub data and maintain research data (including software code, where it is necessary for interpreting the data itself) for initial use and later re-use.
3	Formal analysis	LS	Application of statistical, mathematical, computational, or other formal techniques to analyse or synthesize study data.
4	Funding acquisition	n/a – not funded	Acquisition of the financial support for the project leading to this publication.
5	Investigation	LS, KDC, MJP	Conducting a research and investigation process, specifically performing the experiments, or data/evidence collection.
6	Methodology	LS	Development or design of methodology; creation of models.
7	Project administration	LS	Management and coordination responsibility for the research activity planning and execution.
8	Resources	DM	Provision of study materials, reagents, materials, patients, laboratory samples, animals, instrumentation, computing resources, or other analysis tools.
9	Software	n/a	Programming, software development; designing computer programs; implementation of the computer code and supporting algorithms; testing of existing code components.
10	Supervision	LS, DM, JG	Oversight and leadership responsibility for the research activity planning and execution, including mentorship external to the core team.
11	Validation	LS, KDC, MJP	Verification, whether as a part of the activity or separate, of the overall replication/reproducibility of results/experiments and other research outputs.
12	Visualization	LS	Preparation, creation and/or presentation of the published work, specifically visualization/data presentation.
13	Writing – original draft	LS	Preparation, creation and/or presentation of the published work, specifically writing the initial draft (including substantive translation).
14	Writing – review & editing	LS, KDC, MJP, JCB, JG, DM, LAS, SES	Preparation, creation and/or presentation of the published work by those from the original research group, specifically critical review, commentary or revision – including pre- or post-publication stages.

References

1. Moher D, Shamseer L, Cobey KD, *et al.*: **Stop this waste of people, animals and money.** *Nature.* 2017; **549**(7670): 23–5.
PubMed Abstract | Publisher Full Text
2. Beall J: **Predatory publishers are corrupting open access.** *Nature.* 2012; **489**(7415): 179.
PubMed Abstract | Publisher Full Text
3. van Dyck C: **The Long-Term Preservation of Open Access Journals.** *DOAJ News Service.* 2018. [cited 2019 Oct 23].
Reference Source
4. Macleod MR, Michie S, Roberts I, *et al.*: **Biomedical research: increasing value, reducing waste.** *Lancet.* 2014; **383**(9912): 101–4.
PubMed Abstract | Publisher Full Text
5. Lane J: **Let's make science metrics more scientific.** *Nature.* 2010; **464**(7288): 488–9.
PubMed Abstract | Publisher Full Text
6. Macilwain C: **Science economics: What science is really worth.** *Nature.* 2010; **465**(7299): 682–4.
PubMed Abstract | Publisher Full Text
7. Larivière V, Sugimoto CR: **Do authors comply when funders enforce open access to research?** *Nature.* NLM (Medline); 2018; **562**(7728): 483–6.
PubMed Abstract | Publisher Full Text
8. Suber P: **Open Access Overview. Focusing on open access to peer-reviewed research articles and their preprints**. 2015. [cited 2017 Sep 29].
Reference Source
9. US National Institutes of Health: **How Papers Get Into PMC**. 2015. [cited 2020 Jan 24].
Reference Source
10. US National Institutes of Health: **PMC and Research Funder Policies**. 2019. [cited 2020 Jan 24].
Reference Source
11. E PMC: **Funders - About - Europe PMC.** [cited 2020 Jan 24].
Reference Source
12. Moher D, Srivastava A: **You are invited to submit...** *BMC Med.* 2015; **13**(1): 180.
PubMed Abstract | Publisher Full Text | Free Full Text
13. Clemons M, de Costa E Silva M, Joy AA, *et al.*: **Predatory Invitations from Journals: More Than Just a Nuisance?** *Oncologist.* 2017; **22**(2): 236–40.
PubMed Abstract | Publisher Full Text | Free Full Text
14. Nelson N, Huffman J: **Predatory Journals in Library Databases: How Much Should We Worry?** *Ser Libr.* 2015; **69**(2): 169–92.
Publisher Full Text
15. Somoza-Fernández M, Rodríguez-Gairín JM, Urbano C: **Presence of alleged predatory journals in bibliographic databases: Analysis of Beall's list.** *El Prof*

la Inf. 2016; **25**(5): 730–737.
Publisher Full Text

16. Topper L: **RE: How predatory journals leak into PubMed.** *CMAJ.* 2018. [cited 2020 Jan 8].
Reference Source

17. Manca A, Moher D, Cugusi L, *et al.*: **How predatory journals leak into PubMed.** *CMAJ.* 2018; **190**(35): E1042–5.
PubMed Abstract | Publisher Full Text | Free Full Text

18. US National Library of Medicine: **Fact Sheet MEDLINE® Journal Selection.** U.S. National Library of Medicine. [cited 2019 Dec 5].
Reference Source

19. DOAJ: **Applications: a note about Archiving and Preservation.** *DOAJ Blog.* 2015.
Reference Source

20. Carpenter J: **Researchers of Tomorrow: The research behaviour of Generation Y doctoral students.** Hlava MMK, editor. *Information Services & Use.* 2012; **32**(1–2): 3–17.
Publisher Full Text

21. Dallmeier-Tiessen S, Darby R, Goerner B, *et al.*: **Highlights from the SOAP project survey. What Scientists Think about Open Access Publishing.** *Arxiv.* 2011. 1101.5260.
Reference Source

22. Charbonneau DH, McGlone J: **Faculty experiences with the National Institutes of Health (NIH) public access policy, compliance issues, and copyright practices.** *J Med Libr Assoc.* 2013; **101**(1): 21–5.
PubMed Abstract | Publisher Full Text | Free Full Text

23. Neylon C: **Science publishing: Open access must enable open use.** *Nature.* 2012; **492**(7429): 348–9.
PubMed Abstract | Publisher Full Text

24. Shamseer L, Moher D, Maduekwe O, *et al.*: **Potential predatory and legitimate biomedical journals: can you tell the difference? A cross-sectional comparison.** *BMC Med.* 2017; **15**(1): 28.
PubMed Abstract | Publisher Full Text | Free Full Text

25. **Court Rules in FTC's Favor Against Predatory Academic Publisher OMICS Group; Imposes $50.1 Million Judgment against Defendants That Made False Claims and Hid Publishing Fees.** *Federal Trade Commission Press Releases.* 2019. [cited 2019 Jun 10].
Reference Source

26. Shen C, Björk BC: **'Predatory' open access: a longitudinal study of article volumes and market characteristics.** *BMC Med.* 2015; **13**(1): 230.
PubMed Abstract | Publisher Full Text | Free Full Text

27. Björk BC, Solomon D: **The publishing delay in scholarly peer-reviewed journals.** *J Inf.* 2013; **7**(4): 914–23.
Publisher Full Text

28. van Noorden R: **Gates Foundation research can't be published in top journals.** *Nature.* 2017; **541**(7637): 270–270.
PubMed Abstract | Publisher Full Text

29. van Noorden R: ***Science* journals permit open-access publishing for Gates Foundation scholars.** *Nature.* 2017.
Publisher Full Text

30. van Noorden R: ***Science* journals end open-access trial with Gates Foundation.** *Nature.* 2018; **559**(7714): 311–2.
PubMed Abstract | Publisher Full Text

31. Nasser M, Clarke M, Chalmers I, *et al.*: **What are funders doing to minimise waste in research?** *Lancet.* 2017; **389**(10073): 1006–7.
PubMed Abstract | Publisher Full Text

32. deVito NJ, French L, Goldacre B: **Noncommercial Funders' Policies on Trial Registration, Access to Summary Results, and Individual Patient Data Availability.** *JAMA.* 2018; **319**(16): 1721–1723.
PubMed Abstract | Publisher Full Text | Free Full Text

33. Viergever RF, Hendriks TCC: **The 10 largest public and philanthropic funders of health research in the world: what they fund and how they distribute their funds.** *Health Res Policy Syst.* 2016; **14**: 12.
PubMed Abstract | Publisher Full Text | Free Full Text

34. Whitlock EP, Dunham KM, DiGioia K, *et al.*: **Noncommercial US Funders' Policies on Trial Registration, Access to Summary Results, and Individual Patient Data Availability.** *JAMA Netw Open.* 2019; **2**(1): e187498.
PubMed Abstract | Publisher Full Text | Free Full Text

35. Xia J, Harmon JL, Connolly KG, *et al.*: **Who publishes in "predatory" journals?** *J Assoc Inf Sci Technol.* 2015; **66**(7): 1406–17.
Publisher Full Text

36. Goldacre B: **The WHO joint statement from funders on trials transparency.** *BMJ.* 2017; **357**: j2816.
PubMed Abstract | Publisher Full Text

37. Jackson JL, Kuriyama A, Anton A, *et al.*: **The Accuracy of Google Translate for Abstracting Data From Non-English-Language Trials for Systematic Reviews.** *Ann Intern Med.* 2019; **171**(9): 677–679.
PubMed Abstract | Publisher Full Text

38. Dwan K, Gamble C, Williamson PR, *et al.*: **Reporting of clinical trials: a review of research funders' guidelines.** *Trials.* 2008; **9**(1): 66.
PubMed Abstract | Publisher Full Text | Free Full Text

39. Adjei KOK, Owusu-Ansah CM: **Publishing preferences among academic researchers: Implications for academic quality and innovation**. 2016.
Reference Source

40. Wakeling S, Spezi V, Fry J, *et al.*: **Academic communities: The role of journals and open-access mega-journals in scholarly communication.** *J Doc.* 2019; **75**(1): 120–39.
Publisher Full Text

41. Topper L, Boehr D: **Publishing trends of journals with manuscripts in pubmed central: Changes from 2008-2009 to 2015-2016.** *J Med Libr Assoc.* 2018; **106**(4): 445–54.
PubMed Abstract | Publisher Full Text | Free Full Text

42. **Wellcome updates open access policy to align with cOAlition S | Wellcome.** [cited 2019 Oct 27].
Reference Source

43. Peterson AT, Johnson PE, Barve N, *et al.*: **The NIH public access policy did not harm biomedical journals.** *PLoS Biol.* 2019; **17**(10): e3000352.
PubMed Abstract | Publisher Full Text | Free Full Text

44. National Institutes of Health (NIH): **NOT-OD-18-011: Statement on Article Publication Resulting from NIH Funded Research.** [cited 2018 Jan 15].
Reference Source

45. Lalu MM, Shamseer L, Cobey KD, *et al.*: **How stakeholders can respond to the rise of predatory journals.** *Nat Hum Behav.* 2017; **1**(12): 852–5.
PubMed Abstract | Publisher Full Text

46. Tenopir C, Dalton E, Fish A, *et al.*: **What Motivates Authors of Scholarly Articles? The Importance of Journal Attributes and Potential Audience on Publication Choice.** *Publications.* 2016; **4**(3): 22.
Publisher Full Text

47. National Institutes of Health: **Plan for Increasing Access to Scientific Publications and Digital Scientific Data from NIH Funded Scientific Research**. 2015.
Reference Source

48. Morris S: **The true costs of scholarly journal publishing.** *Learn Publ.* 2005; **18**(2): 115–26.
Publisher Full Text

49. Berger M, Cisarella J: **Beyond Beall's List: Better understanding predatory publishers.** *Coll Res Libr News.* 2015; **76**(3): 132–5.
Publisher Full Text

50. Tao T: **India's Fight Against Predatory Journals: An Interview with Professor Bhushan Patwardhan.** *The Scholarly Kitchen.* 2020. [cited 2020 May 1].
Reference Source

51. Patwardhan BK, Nagarkar S, Gadre SR, *et al.*: **A critical analysis of the 'UGC-approved list of journals'.** *Curr Sci.* 2018; **114**(6): 1299–303.
Publisher Full Text

52. Patwardhan B: **Why India is striking back against predatory journals.** *Nature.* 2019; **571**(7763): 7.
PubMed Abstract | Publisher Full Text

53. Graham ID, Logan J, Harrison MB, *et al.*: **Lost in knowledge translation: time for a map?** *J Contin Educ Health Prof.* 2006; **26**(1): 13–24.
PubMed Abstract | Publisher Full Text

54. Michie S, Richardson M, Johnston M, *et al.*: **The Behavior Change Technique Taxonomy (v1) of 93 Hierarchically Clustered Techniques: Building an International Consensus for the Reporting of Behavior Change Interventions.** *Ann Behav Med.* 2013; **46**(1): 81–95.
PubMed Abstract | Publisher Full Text

55. Anderson K: **Lessons from the Demise of PubMed Central Canada.** Caldera Publishing Solutions. 2018.
Reference Source

56. Seethapathy GS, Santhosh JU, Hareesha AS: **India's scientific publication in predatory journals: need for regulating quality of Indian science and education.** *Curr Sci.* 2016; **111**(11): 1759–1764.
Publisher Full Text

57. Kolata G: **Many Academics Are Eager to Publish in Worthless Journals.** The New York Times. 2017.
Reference Source

58. Bagues M, Sylos-Labini M, Zinovyeva N: **A walk on the wild side: 'Predatory' journals and information asymmetries in scientific evaluations.** *Res Policy.* 2019; **48**(2): 462–77.
Publisher Full Text

59. Cappell MS: **List predatory journal publications separately from genuine scholarly publications as standard for CVs.** *BMJ.* 2015; **350**: h2470.
PubMed Abstract | Publisher Full Text

60. Pond BB, Brown SD, Stewart DW, *et al.*: **Faculty applicants' attempt to inflate CVs using predatory journals.** *Am J Pharm Educ.* American Association of Colleges of Pharmacy; 2019; **83**(1): 7210.
PubMed Abstract | Publisher Full Text | Free Full Text

61. De Solla Price DJ: **Little science, big science.** Columbia Univ. Press; 1963; 119.
Publisher Full Text

62. Shamseer L, Brehaut J, Stewart LA, *et al.*: **Extracted Data**. 2020.
http://www.doi.org/10.17605/OSF.IO/YUDP4

63. Shamseer L, Cobey K, Page MJ, *et al.*: **Study Forms**. 2021.
http://www.doi.org/10.17605/OSF.IO/FSUQ2

64. Shamseer L, Cobey K, Page MJ, *et al.*: **Study Protocol**. 2021.
http://www.doi.org/10.17605/OSF.IO/J6CSK

65. Shamseer L, Cobey K, Page MJ, *et al.*: **Audit of health research funder policies and recommendations on journal publication of research**. 2021.
http://www.doi.org/10.17605/OSF.IO/Z59U6

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Chapter 7: Thesis Discussion

The research in this thesis was initiated in 2015 at a time when predatory journals and their published content were not widely understood and when there was little empirical research to inform discussions and opinions of them. Since then, prominent concerns about predatory journals have persisted, namely that (i) they apply little, if any, filter (i.e., peer review) to submissions (1); (ii) some researchers are mistaking them for legitimate journals (2); (iii) they are deceptive about their practices and costs (3,4), and, (iii) some academics are using them as an opportunity to enhance their career advancement potential (5). General concerns about the system of scholarly publishing have also arisen alongside predatory publishing: that journals are not currently sufficiently transparent in order for researchers to gauge their credibility (6); that peer review in legitimate journals may be questionable (1); that researchers across the globe may not be well informed/equipped to select a journal meeting the basic premise of publishing (7,8) - that published research will be available for future researchers to discover and access in perpetuity. This chapter discusses predatory journals as a signal of broader problems in scholarly and scientific publishing overall.

Summary of research aims

The research in this thesis focused on the characterisation of predatory journals, their content, and the guidance available to help researchers select journals for publication. Before this research was undertaken many aspects of predatory publishing were unclear. ***First***, despite Jeffrey Beall's efforts in alerting us to the potential problem of predatory publishing, his prevailing lists of predatory journals and publishers (Beall's List) was known to be irreplicable and non-evidence based (9–11). There was also a lack of empirical evidence investigating predatory journals, including whether and how they systematically differed from legitimate journals. ***Second***, multiple investigations had been done revealing the failings of peer review in predatory journals to detect purposely and obviously fabricated research articles (1,12). The remaining content of predatory journals, however, if any, was otherwise uncharacterised. ***Third***, whether health research funders provided researchers with any guidance for selecting journals in which to publish funded research was unknown.

Summary of research findings

To address the ***first*** research aim the study in **Chapter 2** was done to assess the differences and similarities between predatory journals and legitimate journal publishers – both open access and subscription-based. Based on the findings of this research, at least 13 features were identified as potential signals of predatory journals (Chapter 2, Table 10). For example, websites of predatory journals appeared to contain more spelling errors, distorted or potentially unauthorized images (assessed using a 'similar image' search in

Google Chrome[1]), listed editors with affiliations to the journal that could not be verified by third-party online profiles, and had substantially lower article processing charges (APCs) (median $100 USD) than legitimate journals. Predatory journals were also similar to legitimate journals in some ways. For instance, 96% of predatory journals, 100% of legitimate open access journals and 95% of legitimate subscription-based journals indicated being peer-reviewed. Eighty-nine percent of predatory journals also claimed to "open access" as did 95% of legitimate open access journals.

To address the ***second*** research aim the research in Chapter 4 was done to investigate epidemiological and reporting of biomedical research published in predatory journals. Data from over 2,000,000 humans and over 8,000 animals were reported across a sample of 1907 clinical or translational primary research studies and systematic reviews published in predatory journals. The corresponding or senior authors of studies were distributed globally, with over half (57%) being from higher (upper-middle income and high) income countries. Of studies we expected to have ethics approval (i.e., primary studies of whole humans or animals, n=1817), only 40% reported having it. Seventeen percent of studies (n=323) indicated having financial support; the most frequently named funder was US National Institutes of Health (n=41, 13%).

We also assessed the reporting quality of studies in the sample, using items from corresponding reporting guideline checklists. Reporting was assessed as variable and as poor overall. For instance, trial registration and participant flow information were each reported in less than 14% of randomized trials, whereas trial objectives were stated 100% of the time. Across 201 preclinical studies evaluated, the most frequently completely reported items were the title/abstract, study objective and a description of the control group (each reported ≥92% of the time); however other essential study characteristics, such as whether assessors were blinded, whether any criteria was used to select animals, and whether adverse events were each reported ≤6% of the time.

To address the ***third*** aim, the research in Chapter 6 was done to investigate whether health non-commercial research funders had recommendations or policies about selecting journals in which to publish funded research. The public websites of 50 non-commercial health research funding organizations (including 46 of the world's largest by expenditure and four from low-income countries) included on the list at healthresearchfunders.org were investigated. Six funders in our sample list did not directly fund health research and no replacement funders were available in the sampling categories. Thirty eight of 44 funders had guidance pertaining to the dissemination of research outputs and almost all (n=36, 95%) recommended or required journal publication. Just over a third of funders provided some level of guidance on journal selection and six listed recommended or required features of publishing journals and publishers. One funder (the Canadian International Development Research Council) provided specific guidance for identifying both credible and questionable journals. Surprisingly, the three funders from India in our

[1] One predatory journal appeared to have an image similar to the Elsevier logo of a tree.

sample did not mention predatory journals or journal credibility despite the overarching initiative by the University Grants Commission (regulator and funder of high education across India) to combat predatory journals ongoing since 2016 (13). Less than a quarter of funder policies/recommendations in the sample included information about monitoring publications. Only two policies (Wellcome Trust and Bill & Melinda Gates Foundation) indicated that published articles would be evaluated to ensure they are published in journals meeting funder requirements. Additionally, the Wellcome Trust and the NIH that payments would be withheld or suspended if funded research publications were in breach of their open access policies. Overall, the policies of major health research funders did not appear to forbid, prevent or mention publication in predatory journals.

Strengths of this research

Below is a summary of the strengths of the research questions, methods, and contributions of each study presented in this thesis.

The research in **Chapter 2** aimed to compare the outward appearance of three distinct groups of journals (predatory, legitimate open access, and subscription-based). This question was appropriate to investigate since researchers report mistaking predatory journals as legitimate (14–16). This study provided several novel contributions to our understanding of predatory journals:

- It was the first empirical evaluation of characteristics of predatory journals, including practices depicted as deficient or compromised by Jeffrey Beall
- it was the first characterisation of predatory alongside presumed legitimate journals.
- it was the first investigation into predatory journals with a biomedical scope

Our findings were consistent with some pre-existing assumptions about predatory journals and additionally provided potentially new insight into the operations of legitimate journals. In line with previous findings, biomedical predatory journals appeared to be disproportionately based in lower income countries. In contrast, legitimate journals in our sample had little presence in such countries. Predatory journals appeared describe themselves as open access and peer reviewed at similar frequencies to legitimate journals. Additionally, the features presented in the discussion as frequent and readily observable on journal websites may provide authors with a starting point for signals about the legitimacy of a journal.

Before the research in **Chapter 4** was done, our knowledge about what predatory journals publish was limited to the purposely flawed studies investigating their absent or poor peer review (1,17,18). This study was the first to comprehensively characterise the epidemiology and reporting research in predatory journals. This study additionally focused on biomedical research due to the volume of research, publishing norms (i.e., higher prevalence and popularity of author-paid open access journals), and its more immediate implications on population health in this field relative to others (19–21). Some of our findings differed from previous research examining predatory journals across disciplines.

For instance, the majority of corresponding or senior authors (57%) in our sample appeared to based in higher income countries whereas authors have been characterised as being disproportionately from lower income countries in previous research (7). We additionally identified, for the first time, that some research in predatory journals appeared to have been funded (some by high well-known health research funders) or ethically approved, thus indicating some level of prior vetting and potentially, of third-party accountability. We also assessed the completeness of reporting be poor overall. This provided, for the first time, a potential indication of the rigour and quality of content published research in predatory journals.

Before the research in Chapter 6, it was unknown whether health research funders provided any guidance around the selection of journals in which to publish funded research. Our findings show that funders appear to provide very little support/recommendations or monitoring in this regard. This research was important since funded biomedical research has been identified in predatory journals (in Chapter 4). Additionally, this research was particularly timely given the potential forthcoming changes in many funders' policies due to Plan S – an international effort led by European funders to ensure that funded research is only published in journals with predetermined open and transparent practices (22). As such, this research may be a useful baseline of funders' pre-Plan S requirements regarding publishing, against which changes over time can be measured.

Limitations of this research

The research in Chapter 2 aimed to characterise how predatory journals *appear* to operate rather than how they *actually* operate. The former is important since there has been long-standing confusion about how to determine the legitimacy of a journal when first encountered (i.e., before engaging with a journal). However, this study did not verify the truthfulness of journal claims. Additionally, we initially intended to statistically compare the features of predatory journals to non-predatory journals. However, we ultimately did not see the utility in such a comparison given that predatory journals are have been found to misrepresent how they operate (i.e., mimic legitimate journals) and the extent to which they do so is unclear. We did not feel such comparisons would clarify the differences between predatory and legitimate journals. The exploratory findings in this chapter provide a strong basis for investigating predatory journal operations and whether they align with what such journals claim on their websites (e.g., are journals indexed in the databases they claim to be). Such research may be helpful in understanding the accuracy of information presented on predatory journals' websites and the extent of potential deception around their practices.

While this study examined Beall's list standalone journals, predatory publishers (i.e., with fleets of journals) are also known to exist. The former, however, have been documented as publishing substantially more content than the latter and as such were appropriate for study (23). Future research could be done to determine when journals from such publishers operate differently than standalone journals. Additionally, the range of

legitimate journals is also known to be broader than that investigated in this study. Future research could be done to compare predatory journals to legitimate journals perceived to be of low quality. For instance, these could be identified as scientific journals found in Ulrich's Periodicals Directory which are not indexed in Medline or Web of Science (i.e., which may potentially not meet indexing standards required by such databases).

The range of features we evaluated, including those highlighted in Table 10, are not intended as "criteria" or as a checklist for defining predatory journals. We did not describe them as such or carry out any exercises of validity or reliability. Unfortunately they have been mistaken in this context by some (24). Future research could investigate the validity and reliability of these features in distinguishing predatory from legitimate journals.

The findings and conclusions in Chapter 4 (i.e., that people and animals are being wasted when research is published in predatory journals) are predicated on the notion research in predatory journals may be of potentially value or may be trustworthy. While the adjudicated the reporting of such research was poor, further investigations into additional components of research trustworthiness ought to be done. While predatory journals have repeatedly been shown to accept articles which have been purposely fabricated to expose their poor operations (1,25), evaluating the trustworthiness of content sent to them in earnest, such as may be represented in Chapter 4, may also be worthwhile. This is important since legitimate journals are also known to accept false and fabricated research. For instance, in John Bohannon's famous 'sting' exposing a high acceptance rate (60%) of fabricated research in predatory journals, 40% of accepting journals were sourced from a database of perceived legitimate open access journals. There are other examples as well. In 1996, a physicist submitted a fake paper about the philosophical application of quantum theory which was accepted for publication in a special science issue of a humanities journals called *Social Text* (26). In 2014 over 120 articles comprising automatically-generated random text, were found in 30 conference proceedings published by two subscription-based publishers (27). Additionally, fraudulent research is increasingly being detected at legitimate journals (28,29). Such revelations are typically based on months-long and sometimes years-long investigations, undertaken by a combination of contributors and parties (30). Given the potential for compromised and potentially untrustworthy research to appear in both predatory and legitimate a comparison of the potentially trustworthiness of research between predatory and legitimate journals ought to be done.

The study in Chapter 6 was limited in its characterisation of health research funders from lower income countries because there was limited representation of such funders in the source we sampled from (we were able to obtain data on three funders located in India [lower-middle income]). Comprehensive data about health research funder expenditures, globally, is sparse and limits researchers' ability to sample and compare funders on this basis. Further investigation into health research funding bodies in lower income countries is worthwhile to both characterise their recommendations and policies about disseminating research outputs and selecting journals.

Contributions to epidemiology

The research in this thesis made several methodological and clinical contributions to epidemiology as outlined in Table 1.

Table 1: Methodological and clinical contributions to epidemiology

	Chapter 2 (characterising journals)	**Chapter 4 (characterising predatory journal research)**	**Chapter 6 (funder policies)**
Clinical	Relevant research may never contribute to evidence-based decision-making based on the presence or absence of journal practices, such as those to ensure the discoverability and permanence of published content.	Potentially valuable data resulting from human and animal contributions may be wasted if journals are not discoverable or permanently available.	Unclear & unmonitored funder publishing policies may contribute to research wastage
Methodological	First study to systematically depict the operations of predatory and non-predatory journals; some features detected in predatory journals may signal that a journal may be predatory/on Beall's list.	First indication of the epidemiology and reporting quality of biomedical research published in predatory journals; poor reported studies may provide a signal that peer review is absent or minimal in predatory journals	First study examining publishing requirements of funders; provides a baseline for future study/audit.

Interpretation of findings

Predatory journals and the research they publish have been portrayed as a distinct subset of the scholarly publishing landscape. The findings from this thesis both agree and disagree with such depictions to varying degree. Across the publishing landscape, there appears to be a lack of transparency in journal practices and policies, regardless of whether the publishing paradigm is subscription or open access, or whether regarded as credible or non-credible. Researchers appear to be publishing their scientific findings in predatory journals and the importance and implications of this requires further consideration. So far,

health research funders appear to provide little guidance to researchers on navigating the journal landscape, despite encouraging the publication of funded research.

In a 2019 blog post Richard Smith, former Editor-in-Chief of the BMJ and vocal proponent of open access publishing, suggested that the value of scientific journals is in the science they publish, rather than in the "trivial" processes they may (or, incidentally, may not) apply (31). The section below debates the triviality of some journal processes in relation to predatory and legitimate journals and the potential impact of journal process on the value, and further, trustworthiness of published research. Lastly, this section explores why an essential gatekeeper in the research process, health research funders, provide little recommendations or policies towards ensure that outputs of funded research are being adequately disseminated (e.g., published in discoverable journals).

Not all journal processes are "trivial"

Some processes that journals carry out improve the value of what is published. In 2018, the Society for Scholarly Publishing (SSP) documented at least 102 processes that publishers carry out to add value to published content (32). Many items on the list include technical and technological processes that optimize the communication of published research, for example: preparing multiple formats (HTML, XML) for published articles required for indexing in various databases; integrating analytics so that citations and other references to articles can be counted; ensuring a permanent digital record of all journal content; creating and tagging metadata for each published article (such as unique digital object identifiers [DOIs]), to facilitate its indexing and discoverability. SSP noted digital archiving as a 'hallmark' of journal legitimacy (32), likely since without it, there is no assurance an article will be found beyond the lifespan of a journal. Archiving is also an eligibility requirement for journals indexed in databases such as Medline (33). In Chapter 1, the example of CrossRef banning *OMICS* gives some indication that membership to its services (registering metadata and allocating DOIs) may also be regarded, at least among the publishing community[2], as a potential marker of legitimacy. Ensuring permanence and discoverability of published research appear to be necessary towards ensuring the basic promise and perhaps, premise of scholarly publishing – to make the results of research available and known for others to build upon (34). In Chapter 2, 6% of predatory journals and less than half of legitimate journals describe their archiving arrangements. Despite not consistently providing this information, we can assume that legitimate journals included in Chapter 2 are archived by virtue of their being sourced from Medline and PubMed Central (PMC)[3]. However, we have little such assurance for predatory journals given their haphazard identification by Beall and others. Knowledge of whether journals are carrying out particular practices are vital to our understanding/assessment of their legitimacy.

[2] an organization of scholarly publishing professionals and publishers
[3] PMC serves as a digital archive (180)

Are some journal processes "trivial"?

The value of some processes carried out by journals may be uncertain. Peer review - the assessment of researchers' work by external, professional peers (35) – is one such process. Despite being a distinguishing feature of scholarly journals and being present in some form for nearly 300 years (36), empirical evidence evaluating the effect of peer review on the quality of biomedical research submitted to journals is weak and suggests trivial effects (37–39). Since predatory journals have emerged, however, rhetoric has been that they and their content are not trustworthy precisely because they are not peer reviewed (4,40,41). By default, legitimate peer-reviewed journals and their content are positioned as trustworthy despite evidence that this is not consistently true (i.e., retractions due to errors and fraud) (28,29). Some untrustworthy studies that have been peer reviewed by and published in legitimate journals have gone on to significantly, and negatively, affect public health (42). This begs the question – what is the specific purpose of peer review and what do we expect it to accomplish?

In Chapter 2, predatory journals indicated being peer reviewed at a similar rate to their legitimate counterparts. This is consistent with findings from John Bohannon's seminal investigation of acceptance rates of fabricated (and therefor untrustworthy) research in predatory and legitimate open access journals (1). While more legitimate journals than predatory journals rejected the faulty paper in that study, most rejections from the former occurred prior to peer review. A less discussed finding of that study is that the proportion of journals carrying out peer review in each group was not significantly different, nor were the proportions of acceptances and rejections following peer review. Thus, it can be concluded that the peer review process at legitimate and predatory journals performed equally at accepting and rejecting untrustworthy research.

This example suggests that the presence of peer review ought not to be taken as a guarantee that a journal's content is trustworthy. In fact, in the absence of a universal, operational definition of peer review (i.e., how it should be done) (43), further thought is needed about the appropriateness of using peer review as a signal of trustworthy research or about its usefulness overall. Accordingly, the most recent definition of predatory journals, determined by consensus, did not consider lack of peer review a defining feature of predatory journals (44).

The value of science

Smith's argument also draws attention to the value of science published in journals. One repeated concern about the value of scientific research published in predatory journals is that it is untrustworthy. The value of journal processes can be debated and supported by evidence. There seems to be agreement and evidence (Chapter 2) that the practices of predatory journals are distinct from those of legitimate journals. However, it cannot necessarily be concluded that journal practices influence the research they publish, as demonstrated by the non-definitive evidence around the effect of journal peer review.

Nonetheless, research in predatory journals is characterised as 'junk' and untrustworthy (1). By default, this positions research in legitimate journals as the opposite. While the research in Chapter 4 found predatory journals to contain poorly reported research (arguably worse than in legitimate journals), conclusions about its trustworthiness may be premature. For instance, in another study evaluating the 'quality' (undefined) of nursing research published in predatory journals, authors concluded that despite the low quality of research examined, it appeared to have been legitimately conducted (45). Inarguably, the retraction of research provides the ultimate signal that research is untrustworthy. The last documented estimate of the rate of retractions in legitimate journals was four in every 10,000 articles; this has been recognized as a gross underestimate due to the haphazard and often lengthy process involved in identifying erroneous or fraudulent research (46). Additionally, questionable research practices such as the failure to replicate or verify initial or prominent research findings, the use of insufficiently powered sample sizes, and selective reporting or publication of findings is purported to affect the majority of research published in legitimate journals (47). Epidemiologist, John Ioannidis, has argued that this compromises the integrity, and thus trustworthiness, of the entire scholarly record (47).

Given this knowledge, it might be worth considering the following:

- While predatory journals may publish untrustworthy research, they may not *only* publish such content.
- While legitimate journals publish trustworthy research, they may not *only* publish such content.

Figure 1 depicts a state of scholarly publishing that represents this scenario. Current perceptions about predatory publishing focus on 'a' and 'd', with little acknowledgment of the prevalence of each, or of 'b' and 'c'. Our current knowledge about scholarly publishing is largely driven by the assumption that 'a' represents the majority of the scholarly record and that 'b', representing fraudulent, erroneous, and otherwise questionable research, is generally a minor exception. For some, 'b' may additionally represent an acceptable level of uncertainty in the scientific process that is assumed to be self-corrected over time (48). However, self-correction, such as in the form of retractions, is not always accounted for in follow-on research (48) nor does it always correct public perception. Consider the difference in potential impact of a fraudulent study being published in an unknown predatory journal compared to being published in a well-known legitimate journal. The relative harm to science (and to the greater human population) from the latter likely outweighs the former. The 1998 publication of a single industry influenced study with falsified data in the *Lancet*, for example, prompted one of the most unnecessary public health crises of our time – a non-negligible and vocal proportion of the public who since fear and resist vaccines in 2020. Could anything be more dangerous in current pandemic caused by the 2019 novel

		Trustworthy Research	
		Yes	No
Legitimate Journal	Yes	a	b
	No	c	d

Figure 1 Journal legitimacy and research trustworthiness

coronavirus (COVID-19) where the potential best solution for stopping its spread is a vaccine? Untrustworthy research of a similar impact has not been documented in predatory journals. Prevailing opinions about the predatory journals tend to highlight the threat of 'd' without acknowledging 'b' and, additionally, with little consideration of the possibility of 'c'.

Chapter 4 provides impetus exists for further consideration of the trustworthiness of research published in predatory journals. Additionally, such research is making its way into the scholarly record through citation in the legitimate literature (49–51), including in systematic reviews (52) which are often used to inform health care decision-making and policy. Research in predatory journals is also known to be indexed in PubMed (53,54) thus resulting in increased detectability by other researchers. This begs the questions: why and how did it get there? PubMed mainly includes content from Medline and PMC which primarily include content from vetted journals. PMC primarily functions as an open access repository for NIH-funded research[4]. Due to NIH's mandatory Public Access Policy, researchers must ensure that a version of their published research is permanently and publicly archived in PMC (55). Therefore, if researchers publish in journals that do not have agreements to deposit content into PMC, researchers must deposit it themselves. It is likely that research published in predatory journals is making its way into PMC through this route. It is also possible that such research is trustworthy in light of it having been vetted and funded by the largest health research funder. A situation whereby an NIH-funded researcher purposely deposits falsified or otherwise knowingly untrustworthy research into their funder's public repository seems unlikely.

The value of science lies in its ability to be trusted independent of where it is published. As a scientific community we ought to reconsider our assumptions about scholarly publishing, particularly around the value added by peer review. This is important beyond predatory journals considering the heightened popularity of another non-peer reviewed outlet for scholarly communications - preprint servers - during COVID-19 (56). If peer review cannot reliably distinguish trustworthy research from that which is not in legitimate journals, then why has its absence (or assumed absence) in predatory journals become the unofficial hallmark of scientific illegitimacy?

Why have funders said little about predatory publishing?

Considering the signals that predatory journals may not be carrying out important journal processes (such as those to facilitate detection of their content), funders ought to be concerned about the waste resulting from funded research being published in them. By nature of their funding research, we can assume that funders place some value on the science that they fund. However, when major health research funders policies were

[4] PMC also facilitates deposition from several other funders who have partnered with PMC, including the UK's top charitable funder, the Wellcome Trust (181).

examined in this thesis, most did not provide minimum journal publishing requirements/guidance for researchers to consider.

A survey by Nature Publishing Group found that only 25% of almost 8500 funded researchers asked were aware of their funders' policies (57). This suggests that funders may not currently be well positioned to affect researchers' decision-making around publishing. Funders with open access mandates (comprising the majority of those sampled Chapter 6) may have an opportunity to improve this situation. One possibility for setting minimum journal requirements is by hinging funding for APCs on journal choice. By doing this, they can vet researchers' journal choice prior to disbursing payment. While this may not be practical for some funders due to the time and related costs involved, the European funder-led 'Plan S' set to take effect in January 2021, demonstrates the commitment some funders are making in order to ensure optimal dissemination of funded research. Plan S aims to leverage funder authority in this manner to ensure open access to research publications by distributing APC funds at the time of publication provided the selected journals meet pre-specified publishing requirements (22). Some of the requirements include that publishing journals must assign persistent identifiers for all scholarly publications; deposition of digital content with a long-term preservation or archiving program; provision of high-quality article-level metadata that includes the name of the funder, and machine-readable information on open access and licensing. In addition to setting minimum requirements, automated tools may be useful in implementing them. For example, Chronos is a publication tracking system originating at the Bill and Melinda Gates Foundation (now broadly available) that facilitates both submission and payment to pre-selected journals. Such a tool may be helpful for other funders to consider in order to both direct submissions to acceptable journals and monitor publications of funded research.

Funders also have the option of sanctioning researchers who publish in journals that are not compliant with minimum requirements. For instance, they can withhold a portion of previously reserved grant funds or forbid researchers from applying for future funds until compliance is met (i.e., through publication in an appropriate journal or deposition in an acceptable repository). That researcher compliance with funder open access policies is low (58) and that funded research appears in predatory journals (Chapter 4) is unsurprising given that few funders appear monitor their research outputs (Chapter 6). Such outcomes ought to motivate funders to implement better policies and monitor research outputs more closely. So why are funders' publishing expectations of funded researchers absent or unclear? Funders' lack of action may be best understood by characterising their funders' action or inaction around this as a 'behaviour'. Behaviour (B) has been conceptualised as being influenced by and interacting with 3 other elements – capability (i.e., knowledge, skills), opportunity (i.e., environment, social), and motivation ((COM), in a system termed COM-B (59). For any behaviour to occur, there must be the capability and opportunity to engage in it, and the motivation to do the behaviour must outweigh the motivation for competing behaviours (59). For funders, it possible that one or more COM factors are absent. For example, not all funders may have the capabilities (i.e., skills) or opportunity (i.e., available resources) required to develop and deliver effective publishing policies.

Some philanthropic research funding may come from independently wealthy benefactors with little previous experience in distributing funding, developing policies, and with little publishing literacy.

Funders ought to consider the potential value in engaging with potential research outputs prior to dissemination to avoid potential waste related to publishing in a disreputable, non-discoverable journal. Developing and implementing policies that address all aspects of publication openness, including discoverability (e.g., unique, persistent identifiers) and permanence (e.g., archiving), at least two features that appear to be missing in predatory publishing, may serve funder investments well. Such policies may additionally benefit those who act and build on research findings such as decision-makers and other researchers.

Implications and recommendations for practice

Findings from this thesis have several important implications for those participating in scientific publishing such as researchers, journals/publishers, organizations involved in supporting research activities such as funders and institutions, as well as the public. While the provision of knowledge about predatory publishing and its potential threats are necessary and ongoing (60,61), some of the uncertainties about both predatory and legitimate journal practices and their content warrant further consideration and action. In light of this, presented below are recommendations for practice and action that various stakeholder groups with a role in scholarly publishing ought to consider.

1. The transparency of journal practices needs improvement

Chapter 2 revealed predatory and legitimate journals are similarly opaque about essential information. For example, APCs in both predatory *and* legitimate journals are not always obvious/available. Additionally, both predatory and legitimate journals indicate carrying out peer review. While we did not aim to verify the truthfulness of such claims, it is well known that most legitimate journals do not provide data about their editorial and peer review processes (62). This lack of transparency about peer review as well as many other journal processes may help explain why many researchers admit having difficultly distinguishing between predatory and legitimate journals (6,16,63). The infiltration of scholarly publishing with supposed 'predators' ought to provide impetus for a shift towards more transparent practices in legitimate journals going forward. This could be achieved with the creation of minimum journal transparency standards agreed on by stakeholder groups across publishing (6).

Throughout history, there is some documentation of operational standards for journals and publishers (64–66). In 1963, the UK Royal Society proposed "Code for the Publication of New Scientific Journals" outlining safeguards for societies to have in place pertaining to journal management if commercial publishers were involved (67). The Code mainly focused on ensuring that decisions about journals' operations were made in consultation

with a scientific editorial board and legal issues such as copyright, however no consideration appeared to be given to ensuring transparent practices/conduct. In 2017, the Committee on Publication Ethics [COPE] introduced 10 "Core Practices" around which journals and publishers should have robust and well-described public documentation (i.e., be transparent about) (68). These include: allegations of misconduct; authorship and contributorship; handling of complaints or appeals; conflicts of interest; data and reproducibility; ethical oversight; intellectual property issues; journal management; peer review process and training; and post-publication discussion and corrections. COPE's Core Practices are an optimal foundation from which to build journal transparency standards, with added consideration of areas lacking transparency identified in Chapter 2 (i.e., journal pricing and digital archiving).

The development of universally-agreed journal transparency standards will help broad uptake among publishers and potentially broad implementation across journals. This ought to facilitate distinction between journals with non-transparent or suboptimal practices and facilitate journal selection by researchers. Such standards may also enhance trust and help manage expectations about the publishing process between researchers and scholarly journals. For instance, transparent data about a journal's peer review process may provide authors with confirmation that peer review takes place, the expected timeframes of peer review and editorial processes, and knowledge of criteria, if any, by which articles are assessed. Transparent information about other aspects of journals such as their APCs may help researchers or the external organizations supporting them (i.e., institutions or research funders) decide whether a publishing journal meets minimum requirements and allocate APC funding accordingly.

Transparency standards for journals have the potential to facilitate better decision-making by a range of stakeholders involved in the publishing process. If developed, such standards have the added benefit of being used as a framework around which automated technology could be developed to better facilitate journal selection by researchers. Such a development could simultaneously eliminate the reliance on and desire for legitimate journal listings (or designation of "predatory journals" at all) and focus efforts on improving the transparency of well-intentioned, legitimate journals (69).

2. We should stop using Beall's List

Beall's contribution in flagging and shaping understanding of predatory publishing has likely secured his permanent recognition in the history of scientific communications. His List has served as a valuable source of information about predatory publishing becoming the *de facto* listing of predatory journals in its short existence. While Beall's List became defunct in January 2017[5] (16,70), research investigating predatory publishing continues to sample from Beall's List[6] (45,54,63), research libraries still refer researchers to it as a list of

[5] https://web.archive.org/web/20170103170903/https://scholarlyoa.com/

[6] Research in Chapters 2 and 4 sampled from Beall's list prior to its closure.

journals to avoid, e.g., (71–73), and academic institutions continue to use it to make judgments about career advancement (74). This is problematic, not only because it is out of date (23), but because it has been shown to be irreplicable and not adequate for discriminating predatory from non-predatory journals (75–78) (also supported by findings in Chapter 2). Beall's List and blog providing numerous examples of questionable features and practices of predatory publishing that may be a useful starting point for researchers trying to understand predatory publishing or to support journal selection decisions. However, that Beall could no longer sustain his predatory-tracking activities due to "intense pressure" from his university (potentially related to legal actions from implicated publishers) (79), ought to raise alarm bells for those considering his List going forward.

Since the closure of Beall's List, at least two different types of lists have arisen. Some have attempted to retain and update Beall's List by possibly attempting to replicate his subjective methodology (potentially yielding a different selection of journals than Beall would have) (80,81). Cabell's has developed its own systematically and transparently applied criteria to identify predatory journals available to subscribing members; it remains unclear, however, on what evidence, if any, their criteria were derived (82,83). Problematically, the journals comprising various listings of predatory journals are known to differ (78). Sixteen percent of articles published between 2002 to 2012 at a small Canadian business school were found to be in journals on Beall's List (84). When the journals were compared to those in other listings of predatory journals, the proportion of predatory publications decreased to as low as 2% (78).

The reliance on lists that use uncertain, unreliable, and non-evidence-based criteria to define a subset of the scholarly landscape possibly ought to be altogether avoided. Before any list of journals can be relied on, journal transparency standards are urgently needed (as per preceding recommendation). Only once we know whether journals are carrying out a minimum set of practices can we begin to distinguish between those operating optimally and transparently or not.

3. We should seriously reconsider use of the term "predatory journal"

The term "predatory journal" has permeated through scholarly research and publishing communities. It was originally used to define a subset of journals which gave off the appearance of operating in the manner expected of legitimate journals, but which under-delivered on their promised practices. The findings of this thesis suggest that there indeed differences in the way that predatory and presumed legitimate journals appear to operate. While a recent consensus definition of predatory journals could not agree on a better term to define the phenomenon (44), defining a subset of distinctly 'predatory' journals or even legitimate journals in practice may be challenging given the current lack of transparency of journal operations across the scholarly publishing landscape. Legitimate journals may risk classification as predatory because information about their operations and policies are not transparent. For example, almost half of journals indexed in Croatia's Open Access

repository either do not carry out peer review or fail to provide information about peer review on their websites and many do not provide information on publication ethics policies (i.e., plagiarism, process/conditions for correction or retractions) (85). Of 57 Eastern European journals indexed in Medline, few had policies about authorship (60%), contributorship (84%), disclosure of financial support (72%), or clinical trial registration (98%) (86). Such journals ought not be labelled as predatory, however the absence of information about their practices may raise concern. This relates back to the absence of journal transparency standards.

The term "predatory" implies that a particular entity is purposefully 'preying' on vulnerable victims, who in predatory publishing, appear to be researchers. The use of this term in its current context originated with Jeffrey Beall, who's conceptualization of predatory journals, while important, was also flawed (i.e., irreplicable process, erroneous inclusion of legitimate journals) (77,78). Additionally, Beall's discussions of predatory journals repeatedly included derogatory descriptions of publishing in some areas of the world. In one instance he lamented, "I think the industry will continue to select for publishers like these [predatory]…so the future of the scholarly publishing industry looks very much like the textile industry, with most production moved to low-wage countries."[7]. Similarly, in 2015, Beall referred to SciELO[8], the widely used Brazilian-based Open Access publishing platform and database for IbericoAmerican and other non-English research, as a "publication favela"[9]. As a result, the term "predatory" journal may represent xenophobic views for some.

Beall's efforts were also biased towards investigating "open access" [10] journals and he excluded subscription-based journals from his 'predatory' scrutiny. However, the perceived exploitative practices of commercial publishers have been a long-standing concern for researchers. The rapid expansion of commercial publishers, potentially similar to growth of predatory publishers, to accommodate post war expansion into new fields of science raised flags for scientists at the time. This prompted Royal Society president, Howard Florey, to acknowledge and devise the first known Code of Conduct for scholarly journals in 1963 (67).

"The present tendency for commercial publishers to initiate new scientific journals in great numbers is causing concern to many people. With the expansion of established sciences and advances into new fields

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[7] https://scholarlykitchen.sspnet.org/2016/02/08/an-interview-with-jeffrey-beall/

[8] SciELO was integrated into the Web of Science Platform in January 2014, https://blog.scielo.org/en/2014/02/28/scielo-citation-index-in-the-web-of-science/

[9] https://scholarlykitchen.sspnet.org/2015/08/10/defending-regional-excellence-in-research-or-why-beall-is-wrong-about-scielo/

[10] Beall's blog in which he tracked predatory journals/publishers was entitled "Scholarly Open Access"

and disciplines it is evident that new journals are necessary." Howard Florey, president of the Royal Society, 1963 (67)

More recently, the practices of largest scholarly publisher, Elsevier, as well as other subscription-based publishers have been criticized. In 2009, for example, Elsevier admitted to publishing six academic journals containing only favourable research about Merck products, which failed to disclose the company's sponsorship of the journals (87). At that time, these were referred to as "fake journals" (88). Opaque and perceived unfair business practices regarding journal bundling (i.e., 'Big Deals'), have also prompted outrage and protest against Elsevier and other subscription publishers in 2012 in a movement known as the 'academic spring' (89) (90). Since that time, at least 50,000 academics worldwide publicly announced their commitment to boycotting Elsevier journals (i.e., not publishing in, peer reviewing for, or editing them) (91,92). Notably, universities worldwide are increasingly cancelling their 'Big Deals' with subscription publishers because their perceived low cost-benefit ratio (93). Subscription publishers' paywalls imposed on the majority of the global research corpus have also been referred to as "predatory" (94); and much has been written about the capitalistic behaviour of such publishers who claim to "own" content produced by the unpaid contributions of authors, peer reviewers, and editors (95–99).

The use of "predatory" to refer to a distinct set of journals (and, by default, not others) carrying out deceptive practices has become commonplace over the past decade. However, labelling journals using potentially varying expectations of how they ought to operate overall, instead of by their potentially problematic practices, fails to adequately conceptualize the broader problem first signalled by Beall – that some journals are intentionally misrepresenting themselves in order to make money. While attempts have been made to define or re-define the term "predatory journals" beyond Beall's characterisations (44), it is possible that a semantic shift may not adequately capture or characterise predatory practices occurring across the entirety of the scientific publishing landscape (100,101).

Before journals carrying out suspected "predatory" practices can be adequately renamed, the range of existing journals and practices across the entire spectrum of existing journals, including those in regional databases or which have not yet been indexed, must be characterized. Additionally, standards for journal transparency must be developed. Once these two actions are accomplished, we can begin to understand and assign judgment to the adequacy or problematic nature of journal practices.

4. Academic rewards should focus less on where research is published and more on what is published.

Some have suggested that research in predatory journals be discounted from academic evaluations (40,102). The hiring committee from East Tennessee State University in the US,

for example, recommend that academic hiring committees ought to ban applicants with predatory journal publications from applying to academic positions (41). Chapter 4 showed that predatory journals contained biomedical content and that some it had been carried out at well-known institutions and was supported by well-known funders. While the overall reporting quality of the sampled research was assessed to be poor, little else is known about its overall trustworthiness. Without more information, devaluing research contributions published in journals may be premature.

Surveys of researchers indicate that most submit to predatory journals before knowing that they are predatory (2,16,63). Knowing this, there is little rationale for assuming that such research is unworthy of equal consideration to research published in legitimate journals. Punishing researchers for publishing in predatory journals is akin to judging a book by its cover. In the context of academic evaluation, it is not that different from the problematic practice of rewarding academic researchers for publications in high impact journals (103–105). In line with modern recommendations for academic reward and evaluation, assessments ought to focus less on the number and prestige of journal publications and instead assign value to its trustworthiness, relevance, and impact (103,106).

5. Rewarding preprint contributions may reduce predatory publishing

It is possible that some researchers who publish in predatory journals may do so because, for various reasons, they are seeking a lower barrier publishing outlet in which to share their research than legitimate journals tend to offer. Rapid publication and rejection from other journals are the leading reasons researchers indicate submitting to predatory journals (16). Lengthy wait times for editorial decisions and eventual publication in legitimate journals, as well as high rejection rates are prevalent across scholarly publishing (107,108). As such, it is not surprising that researchers may be seeking out publishing outlets willing to both easily accept and rapidly publish research.

The Committee on Publication Ethics (COPE) defines a preprint as "a scholarly manuscript posted by the author(s) in an openly accessible platform, usually before or in parallel with the peer review process." (109). Preprint servers formally originated in the field of physics with the creation of the first online preprint server, arXiv.org (pronounced "archive") in 1991 (110). ArXiv quickly became the norm for sharing unpublished physics research so that researchers could collaborate and receive feedback on their research before submitting to journals (110,111). In 1994, mathematician Frank Quinn pronounced of physicists sharing preprints, "the rest of scholarly publishing has much to learn by watching these bold pioneers" (112). The adoption and launch of preprint servers into other fields has been slow and steady (113). Between 2013 to 2018 at least 18 preprint servers were launched across various disciplines of science (114). The first dedicated biomedical preprint server (medrXiv) was eventually launched in June 2019 (113).

Unlike predatory journals, preprint servers do not purport to peer review research. Instead, they explicitly state which, if any, basic quality control measures are in place, such as ensuring appropriateness for the subject area, non-duplication of content, and ensuring that content represents original research; they also have policies for replacing or withdrawing content found to be problematic (115,116). Some preprint servers accepting biomedical research are known to perform additional quality assurance checks for research ethics approval, where relevant, and for potentially harmful claims before preprints are made publicly available (117). Preprints are increasingly being considered/debated by stakeholders in research (118). COVID-19 has revealed the importance of preprint servers for rapidly disseminating novel, important research (56). However, the pandemic has also demonstrated that not all research published in preprint servers or journals ought to be trusted (119,120).

Preprint servers are intended to provide a venue for research to be shared while it awaits adjudication in a journal. However, historically, biomedical journal editors are known to have resisted their adoption due to the threat they posed – they feared that researchers would be dissuaded from submitting research to journals if it was already in preprint servers and that their role as gatekeepers of integrity of the scholarly record would be diminished (121,122). The 1969 'Ingelfinger rule' originating in the *New England Journal of Medicine* and widely adopted by many other journals until recently, captures some of this sentiment (123). It forbade researchers to disseminate their work prior to journal publication in order to retain "newsworthiness" of the finding upon publication (123). More recently, concerns have focused on the trustworthiness of non-peer reviewed research in preprint servers due to the more serious and immediate implications to the public in medicine compared to other fields (124). This concern demands further attention given the increasing popularity of sharing biomedical preprints – in June 2020, preprints were estimated to comprise at least 8% of the biomedical literature (125).

In physics, evidence shows that researchers continue to submit to journals after submitting to preprint servers. Almost 90% of research in ArXiv in 2000 was eventually published in either abstract or full text form in scholarly journals (126). However, across disciplines, estimates suggest that close to one third of preprints are not published after 24 months of posting, with variation across disciplines (127–129), although publication rates may be underestimated due to known lengthy delays in publishing (i.e., due to rejections, and peer review and article production times (107,108)). Some preprint servers enable direct submission to journals through built-in interfacing with common manuscript submission systems (i.e., Editorial Manager and ScholarOne) (130).

That some research in preprint servers are not eventually published, however, indicates the potential importance of such outlet for research that may otherwise be absent from the scientific record. As such, they have the potential to provide a low barrier, rapid publishing option that researchers may be seeking through predatory journals. They are also superior to predatory journals in several ways:

- **Transparent about lack of peer review:** Among the most questionable practices of predatory journals is whether or not they carry out peer review. Some preprint servers explicitly indicate not being peer reviewed on either their webpage, on each preprint, or both (131). The number of preprint servers which provide such transparency are likely to increase given the increased scrutiny of them and their materials resulting from COVID-19.
- **No fees:** Preprint servers are currently free to 'publish' in *and* are free to access (131). This may permit more equitable participation of researchers in publishing than subscription-based or author-paid open access journals, including predatory journals which collect fees via APCs.
- **Discoverable and permanent:** In 2016, Crossref agreed to start assigning DOIs to content in preprint servers thus formally distinguishing them as a separate publications from eventual journal publications (i.e., not a duplicate publication) (130,132). The presence of a DOI also ensures that preprints are trackable and identifiable in contrast to predatory journals, which are unlikely to secure DOIs due to costs associated with doing so. Further, preprint servers are also permanent archives ensuring access to their content in perpetuity, thus solving another problem presented by predatory journals. As a testament to the importance of preprints, the National Institutes of Health (NIH) also began indexing all NIH-funded preprints in PMC in June 2020, enhancing their discoverability (133).
- **High acceptance rate:** Most preprint servers only aim to filter submissions on the basis of subject area appropriateness, ethics, and plagiarism. This serves a dual purpose of implementing some quality assurance that may not otherwise be carried out by predatory journals while reducing filtration of the scholarly record for citable or otherwise important research by legitimate journals.
- **May incentivize better quality research:** It is possible that the potential of public visibility for research deposited in preprint servers may act as an incentive for researchers to submit higher quality manuscripts to preprint servers than they would to journals, particularly to largely unfiltered predatory journals with low visibility. Data from the field of physics suggests this has been a benefit of preprints (134).

Currently, multiple field-specific and generic catch-all preprint servers exist, including some supported by well-known health research funders such as Wellcome Trust and the Bill and Melinda Gates Foundation (135). Some funders also indicate supporting the inclusion of preprints on CVs as well as their citation in grant applications (130). If those evaluating researchers for career advancement can also find a way to appropriately acknowledge or reward trustworthy preprint contributions, researchers seeking a rapid, low barrier publishing option or who are marginalized by inequities in legitimate scholarly publishing may be incentivized to submit to preprint servers instead of to predatory journals.

Recommendations for future research

Tens of thousands of scientists around the world have published research in predatory journals, including at least 5000 German scientists (136), 5000 British scientists (18), and thousands more from the US, India, and other regions of the world (45,54,137,138). That large numbers of researchers worldwide are publishing in predatory journals demands further and urgent inquiry into the nature of such research. Understanding the trustworthiness of research in predatory journals, for instance, may help us better understand the problems presented by them and potential implications for the integrity of the scholarly record. Additionally, the potential of predatory journals as an outlet for contributions that may be systematically underrepresented or excluded from legitimate journals is also worth investigating. This section outlines research that ought to be done to investigate these proposals.

Examine the trustworthiness of research published in predatory journals

The research in Chapter 4 demonstrates that predatory journals contain biomedical research that, while of poor reporting quality, is of unknown trustworthiness in comparison to legitimate journals. Investigation into the trustworthiness of research published in predatory compared to legitimate journals (and potentially to preprint servers), ought to be done.

A universal conceptualization of trustworthy research does not exist, possibly because trust is a value-based concept that differs according to individual perception (43). One group of researchers who have spent time investigating fraudulent research and behaviours have proposed a checklist aiming to provide signals about the reliability and trustworthiness of research findings (139). The "REAPPRAISED" checklist, published in January 2020, aims to guide assessment of research trustworthiness within 11 categories, each represented by a letter in the acronym[11]. These items relate to funding, ethical oversight, publication ethics, author productivity/workload, methodological validity, and plausibility of results. While the checklist still requires validation, it has already successfully been demonstrated to detect falsified and fabricated research in at one journal (140) and may be worth considering in the absence of another tool.

Revisiting Figure 1 of this chapter research could be done to estimate the risk of (un)trustworthy research, assessed using REAPPRAISED, being published in predatory versus legitimate journals (e.g., {b/a+b}/{d/c+d}). This will provide evidence to guide future discussions and decisions regarding the trustworthiness in publishing. For instance, it can be used to decide whether predatory journals are solely outlets for untrustworthy research (and should be discarded) or whether trustworthy research may be systematically "lost" due to their evidently haphazard indexing (141,142). It may also provide an indication of whether the uncertain divide/labelling of legitimate and predatory journals is necessary.

[11] **R**esearch governance; **E**thics; **A**uthorship; **P**roductivity; **P**lagiarism; **R**esearch Conduct; **A**nalyses and methods; **I**mage manipulation; **S**tatistics and data; **E**rrors, **D**uplicate data and reporting.

As a scientific community we ought to consider valuing research on the basis of its trustworthiness rather than on the basis of where it is published.

Examine the nature of research effects reported in predatory journals

One of the most concerning limitations of the published scholarly record is that it is an incomplete record of the total existing evidence (143). At least 50% of clinical trials are estimated never to be published (144–146); those that are published tend to overestimate treatment effects and underestimate harms (144,147,148). The systematic omission of null and negative findings from the published literature (either through author or journal decisions) is referred to as publication bias (144,149). This is problematic for researchers aiming to conduct comprehensive evidence synthesis to inform decision-making and policies, particularly where the health of populations is concerned. Most systematic reviews, for example, do not carry out searches for unpublished (i.e., "grey") literature, likely due to the considerable effort (involving dedicated resources and expertise) to find unpublished research (150–152). Seeking unpublished evidence may be more important in some scenarios than in others, i.e., when few relevant published studies exist, when cumulative estimates are uncertain, or when clear conflicts of interest exist in the published literature. Research shows that when unpublished literature has been included in meta-analyses, the treatment effects reported in published trials, on average, appear to be 9% larger than those in unpublished trials (150).

Some concerned about the effect of predatory journals on the integrity of the science (153–156) worry that predatory journals are preventing research that would otherwise be published in legitimate journals from entering the scholarly record (155). However, there does not seem to be a decrease in the amount of research being published in legitimate journals since predatory emerged in large numbers starting in 2012. Between 2008 and 2018, the global publication output in science (including health research) and engineering journals, grew steadily at an annual rate of 4%[12] (157). Additionally, studies cumulatively show that researchers are disinclined to submit some research for publication (in legitimate journals), particularly that which they perceive to unfavourable or not important enough to engage in lengthy journal processes (149). Juxtaposed to this is that few legitimate journals (12%, 14/121 high impact factor medical journals) encourage authors to submit manuscripts of robust research "regardless of the direction or strength of the results" (158). It is therefore plausible that researchers are sending research they would otherwise not published to predatory journals due to their low acceptance barrier (and possibly low APCs) (1).

That predatory journals may be a source of legitimate research containing null or negative findings warrants further investigation. Since predatory journals are known to be cited in systematic reviews, research could be done to examine the influence of research published in predatory journals on effect estimates in meta-analyses. Similar studies have previously

[12] Estimated using data from Scopus

been done examining the impact of grey literature (159). Sensitivity analyses of meta-analyses could be done excluding research in predatory journals and compared to original estimates containing such research. Some research to this effect appears to have been initiated (160).

The proposed research would provide vital evidence needed to make further judgements about the importance of research published in predatory journals.

Explore inequities researchers face when selecting journals

Structural barriers in scientific publishing may prevent some populations of researchers from engaging (or fully engaging) in the scholarly discourse (161). For instance, the majority of legitimate scientific journals and publishers are based in higher income, English-speaking countries, and their content is dominated by authors from such countries (162). Researchers from lower income countries are underrepresented in the legitimate scholarly record (163–166) and appear to be overrepresented in predatory journals across disciplines (7). Correspondingly, predatory journals are also predominantly based in lower income countries (137). These differences are somewhat expected since countries with more money are able to support more science, training, and scientists (162). Low income countries typically do not have the funding to put structures in place to support scientific training, research activities (including accessing and publishing in scholarly journals), or sometimes, basic, widespread access to the internet (167). In addition to country income status, researchers may face multiple, intersecting barriers to publish in legitimate journals. For instance, non-native English-speaking researchers may have more difficulty publishing in English. For such researchers who are also from lower income countries, they may have less resources and training to facilitate written English language skills (161), thus preventing acceptance and participation in publishing since the majority of legitimate scientific journals are published in English (162). Additionally, the inability to participate in publishing means that some researchers have less previous publishing experience and may have more difficulty selecting legitimate journals. Indeed, researchers with fewer previous publications appear to be overrepresented in predatory journals compared to legitimate journals (2,7). Researchers from lower income countries may also have difficulty participating in legitimate publishing due to the presence of both conscious and unconscious biases related to the value of the research they produce. Studies indicate that the topics and quality of research originating in lower income countries are regarded as less important and as of lower quality, respectively, by researchers in higher income countries (168–170). This situation can be problematic for lower income researchers aiming to publish in non-domestic or international journals, as a requirement for academic career advancement.

Research, such as a scoping review, ought to be done to understand what factors influence researchers' decisions on where to publish globally. Such research could utilize an intersectionality lens to consider whether and how both structures of power (i.e., in income status and relationships) and social identities (i.e., ethnicity and gender) influence

where researchers' publishing decision-making. Such a review could additionally make use of the 'PROGRESS-Plus' (place of residence-race/ethnicity/culture/language-occupation-gender/sex-religion-education-socioeconomic status-social capital-plus other characteristics) framework (171) to provide a comprehensive identification and categorization of important factors in researchers' decision-making related to publishing.

There is a growing body of literature investigating why researchers publish in predatory journals (14,16,172) and where they choose to publish more generally (173–179). The proposed research may help explain global commonalities and differences that may influence researchers to select legitimate or predatory journals. This research may help to provide a more nuanced understanding of why some groups of researchers/areas of the world are more or less represented in legitimate as well as predatory publishing. This may additionally help support change towards a more inclusive scholarly publishing environment for researchers globally.

Thesis Conclusion

Publishing research makes new knowledge available to others so it can be implemented and used in future knowledge generation. The system of scholarly publishing is also integral to decisions about academic career advancement, including grant allocation and promotion. This interdependence between academia and scholarly publishing, combined with real and perceived barriers to accessing and publishing in legitimate scholarly journals may have created fertile ground for low standard, low barrier publishing entities to capitalize on academic researchers' need to publish in order to advance their careers. Predatory journals and publishers have been known present themselves as carrying out legitimate journal practices even when they do not, to entice researchers to publish with them, and to charge fees from authors who publish with them. The research presented in this thesis found that the websites of biomedical predatory journals are noticeably different to those of legitimate journals in some respects (e.g., have low quality/resolution images and text, promise rapid peer review and publication, and fail to provide retractions policies). Yet they appear to be similar in some ways as well, such as claiming to be open access and peer reviewed. This research also showed, for the first time, that the biomedical content of predatory journals appears to be authored by researchers globally. Some such research also reported financial support from well-known funders and indicated being approved by research ethics boards. As such, such content may warrant further consideration for trustworthiness, particularly if they are entering mainstream databases such as PMC as a result of funders open access policies. Our findings represent some striking differences from previous studies which have implicated lower income researchers as the main contributors to predatory journals and characterised their content largely as fabricated and untrustworthy. If potentially trustworthy research is being published in predatory journals this is problematic because such journals are not consistently included in bibliographic databases typically used by researchers. Additionally, this thesis found that most health research funders do not provided recipients of research funding with advice or guidance about predatory journals or about basic requirements of the journals they

ought to publish funded research in. The absence of such guidance fails to prevent research waste from accruing as a result of predatory publishing.

The ease with which a fee-collecting 'publishing' entity can be set up and the lack of regulations to prevent or control their emergence mean that predatory journals will almost certainly continue to exist. Efforts to contain or curtail them may be wasted. Efforts ought to focus on directing researchers to discoverable publishing outlets, improving the transparency of journal practices, characterise the trustworthiness of research in predatory journals, why they exist, and seek to minimize any harmful consequences. In order to do this, weaknesses in precipitous aspects of the scholarly publishing landscape and in academic reward must be addressed. It is possible that predatory journals are providing an opportunity for research and researchers to be published that would otherwise typically be overlooked by legitimate journals. Such research may include studies reporting null or unfavourable findings, "periphery" research topics affecting lower income populations, and authors belonging to underrepresented groups such as non-native English speakers, those from low-income countries, trainees, and women.

The potential implications of the findings of this thesis affect the scientific and academic communities, the scholarly publishing community, and organizations funding research. That some researchers are being deceived into publishing in predatory journals suggests that characteristics of predatory and legitimate journals are not always distinct or understood. Journals regarded as legitimate, or wishing to be regarded as such, may need be more outwardly explicit about their policies and operations, in order to be more easily distinguished from predatory journals. Further, before banning research articles published in predatory journals from the scientific record, we ought to first evaluate their individual, potential value, integrity, and nature of reported findings. Doing so may help determine whether any research published in predatory journals is potentially valuable and whether, for instance, it should be considered by those systematically synthesizing evidence. Lastly, researchers who publish in predatory journals as a means of achieving rapid, low barrier publications for career advancement, particularly those affected by inequities in publishing, may find preprint servers or post-publication peer reviewed journals an appealing alternative, due to their low-barrier, rapid mechanism for sharing pre-peer reviewed research. If such contributions can be appropriately and adequately rewarded by academic reward systems, this has the potential to direct researchers away from predatory journals. It may also facilitate optimal sharing, discoverability, and uptake of trustworthy research, ensuring its availability in the global evidence base for future knowledge generation. Based on the arguments presented in this chapter, predatory journals could be seen as a potential signal of long-standing problems in the system of scholarly publishing, and the scientific communities' expectations of and reliance on it - in effect, a canary in the coal mine.

References

1. Bohannon J. Who's afraid of peer review. Science. 2013;342:60–5.

2. Bagues M, Sylos-Labini M, Zinovyeva N. A walk on the wild side: 'Predatory' journals and information asymmetries in scientific evaluations. Res Policy. 2019 Mar;48(2):462–77.

3. Moher D, Srivastava A. You are invited to submit…. BMC Med. 2015 Dec;13(1):180.

4. Ferris LE, Winker MA. Ethical issues in publishing in predatory journals. Biochem Medica. 2017 Jun 15;27(2):279–84.

5. Kolata G. Many Academics Are Eager to Publish in Worthless Journals [Internet]. The New York Times. 2017 [cited 2020 Apr 30]. Available from: https://www.nytimes.com/2017/10/30/science/predatory-journals-academics.html?smid=tw-share

6. Samulack D, Roberts J. Guest Post: Transparency – "This is What We Do, and This is What We Expect" [Internet]. The Scholarly Kitchen. 2018 [cited 2018 Dec 12]. Available from: https://scholarlykitchen.sspnet.org/2018/09/11/guest-post-transparency-this-is-what-we-do-and-this-is-what-we-expect/

7. Xia J, Harmon JL, Connolly KG, Donnelly RM, Anderson MR, Howard HA. Who publishes in "predatory" journals? J Assoc Inf Sci Technol. 2015 Jul;66(7):1406–17.

8. Wager E. Why we should worry less about predatory publishers and more about the quality of research and training at our academic institutions. Vol. 27, Journal of Epidemiology. Japan Epidemiology Association; 2017. p. 87–8.

9. Beall J. Criteria for Determining Predatory Open-Access Publishers. 1st Edition. 2012.

10. Beall J. Criteria for Determining Predatory Open-Access Publishers. 2nd Edition. 2012.

11. Beall J. Criteria for Determining Predatory Open-Access Publishers. 3rd Edition. 2015.

12. Mazì D, Kohler E. Get me off Your Fucking Mailing List.

13. Tao T. India's Fight Against Predatory Journals: An Interview with Professor Bhushan Patwardhan [Internet]. The Scholarly Kitchen. 2020 [cited 2020 May 1]. Available from: https://scholarlykitchen.sspnet.org/2020/02/05/indias-fight-against-predatory-journals-an-interview-with-professor-bhushan-patwardhan/

14. Bagues M, Sylos-Labini M, Zinovyeva N. A walk on the wild side: an investigation into the quantity and quality of ' predatory ' publications in Italian academia. LEM Papers

Series. Pisa, Italy.: Laboratory of Economics and Management (LEM), Sant'Anna School of Advanced Studies, Pisa, Italy; 2016.

15. Mccutcheon L, Aruguete MS, Mckelvie SJ, Williams JL. How Questionable Are Predatory Social Science Journals? 2016.

16. Cobey KD, Grudniewicz A, Lalu MM, Rice DB, Raffoul H, Moher D. Knowledge and motivations of researchers publishing in presumed predatory journals: a survey. BMJ Open. 2019 Mar 23;9(3):e026516.

17. Kolata G. For Scientists, an Exploding World of Pseudo-Academia. NYTimes.com. 2016 May 11;

18. Hern A, Duncan P. Predatory publishers: the journals that churn out fake science. The Guardian. 2018;

19. Crawford W. GOAJ3: Gold open access journals 2012-2017. 3rd ed. Livermore, CA; 2018.

20. Piwowar H, Priem J, Larivière V, Alperin JP, Matthias L, Norlander B, et al. The state of OA: a large-scale analysis of the prevalence and impact of Open Access articles. PeerJ. 2018 Feb 13;6(2):e4375.

21. Entwistle V. Reporting research in medical journals and newspapers. BMJ. 1995 Apr 8;310(6984):920–3.

22. 'Plan S' and 'cOAlition S' – Accelerating the transition to full and immediate Open Access to scientific publications [Internet]. [cited 2019 Oct 23]. Available from: https://www.coalition-s.org/

23. Crawford W. Gray OA 2012-2016: Open access journals beyond DOAJ. Cites & Insights. 2017;17(1).

24. Cukier S, Helal L, Rice DB, Pupkaite J, Ahmadzai N, Wilson M, et al. Checklists to Detect Potential Predatory Biomedical Journals: A Systematic Review. medRxiv. 2019 Sep 16;19005728.

25. Neuroskeptic. Predatory Journals Hit By 'Star Wars' Sting [Internet]. Discover Magazine. 2017 [cited 2017 Aug 5]. Available from: http://blogs.discovermagazine.com/neuroskeptic/2017/07/22/predatory-journals-star-wars-sting/#.WlAZN1Q-fOR

26. Sokal AD. A Physicist Experiments With Cultural Studies. Ling Fr. 1996;6(4):62–4.

27. Van Noorden R. Publishers withdraw more than 120 gibberish papers. Nature. 2014 Feb 24;

28. Fang FC, Steen RG, Casadevall A. Misconduct accounts for the majority of retracted

scientific publications. Proc Natl Acad Sci. 2012 Oct 16;109(42):17028–33.

29. Steen RG, Casadevall A, Fang FC. Why Has the Number of Scientific Retractions Increased? Derrick GE, editor. PLoS One. 2013 Jul 8;8(7):e68397.

30. Bolland MJ, Avenell A, Gamble GD, Grey A. Systematic review and statistical analysis of the integrity of 33 randomized controlled trials. Neurology. 2016 Dec 6;87(23):2391–402.

31. Smith R. The New England Journal of Medicine, open access, Plan S, and undeclared conflicts of interest [Internet]. Richard Smith's non-medical blogs. 2019 [cited 2019 Dec 23]. Available from: https://richardswsmith.wordpress.com/the-new-england-journal-of-medicine-open-access-plan-s-and-undeclared-conflicts-of-interest/

32. Anderson K. Focusing on Value - 102 Things Journal Publishers Do (2018 Update) [Internet]. The Scholarly Kitchen. 2018 [cited 2020 Apr 14]. Available from: https://scholarlykitchen.sspnet.org/2018/02/06/focusing-value-102-things-journal-publishers-2018-update/

33. US National Library of Medicine. Fact Sheet MEDLINE® Journal Selection [Internet]. U.S. National Library of Medicine; [cited 2019 Dec 5]. Available from: https://www.nlm.nih.gov/lstrc/jsel.html

34. Price DJ de S. Little science, big science. Columbia Univ. Press; 1963. 119 p.

35. Huston P. Peer Review. CMAJ. 1995;154(4):439.

36. Sherma H. The Birth of Modern Peer Review [Internet]. Scientific American Blog Network. 2014 [cited 2020 Apr 1]. Available from: https://blogs.scientificamerican.com/information-culture/the-birth-of-modern-peer-review/

37. Jefferson T, Rudin M, Brodney Folse S, Davidoff F. Editorial peer review for improving the quality of reports of biomedical studies. Cochrane Database Syst Rev. 2007 Apr 18;(2):MR000016.

38. Hopewell S, Collins GS, Boutron I, Yu L-M, Cook J, Shanyinde M, et al. Impact of peer review on reports of randomised trials published in open peer review journals: retrospective before and after study. BMJ. 2014 Jul 1;349:g4145.

39. Bruce R, Chauvin A, Trinquart L, Ravaud P, Boutron I. Impact of interventions to improve the quality of peer review of biomedical journals: a systematic review and meta-analysis. BMC Med. 2016 Dec 10;14(1):85.

40. Beall J. Ban predators from the scientific record. Nature. 2016 Jun 15;534(7607):326–326.

41. Pond BB, Brown SD, Stewart DW, Roane DS, Harirforoosh S. Faculty applicants'

attempt to inflate CVs using predatory journals. Vol. 83, American Journal of Pharmaceutical Education. American Association of Colleges of Pharmacy; 2019.

42. Wakefield AJ, Murch SH, Anthony A, Linnell J, Casson DM, Malik M, et al. Ileal-lymphoid-nodular hyperplasia, non-specific colitis, and pervasive developmental disorder in children [retracted]. Lancet. 1998;351(9103):637–41.

43. Tennant JP, Ross-Hellauer T. The limitations to our understanding of peer review. Res Integr Peer Rev. 2020 Dec 30;5(1):6.

44. Grudniewicz A, Moher D, Cobey KD, Bryson GL, Cukier S, Allen K, et al. Predatory journals: no definition, no defence. Nature. 2019 Dec 11;576(7786):210–2.

45. Oermann MH, Nicoll LH, Chinn PL, Ashton KS, Conklin JL, Edie AH, et al. Quality of articles published in predatory nursing journals. Nurs Outlook. 2018 Jan 1;66(1):4–10.

46. Brainard J. What a massive database of retracted papers reveals about science publishing's 'death penalty'. Science (80-). 2018 Oct 25;

47. Ioannidis JPA. Why Most Published Research Findings Are False. PLoS Med. 2005 Aug 30;2(8):e124.

48. Jamieson KH, McNutt M, Kiermer V, Sever R. Signaling the trustworthiness of science. Proc Natl Acad Sci. 2019 Sep 24;116(39):19231–6.

49. Anderson R. Citation Contamination: References to Predatory Journals in the Legitimate Scientific Literature [Internet]. The Scholarly Kitchen. 2019 [cited 2019 Nov 8]. Available from: https://scholarlykitchen.sspnet.org/2019/10/28/citation-contamination-references-to-predatory-journals-in-the-legitimate-scientific-literature/

50. Oermann MH, Nicoll LH, Carter-Templeton H, Woodward A, Kidayi PL, Neal LB, et al. Citations of articles in predatory nursing journals. Nurs Outlook. 2019 Nov;67(6):664–70.

51. Björk B-C, Kanto-Karvonen S, Harviainen JT. How Frequently Are Articles in Predatory Open Access Journals Cited. Publications. 2020 Mar 26;8(2):17.

52. Ross-White A, Godfrey CM, Sears KA, Wilson R. Predatory publications in evidence syntheses. J Med Libr Assoc. 2019 Jan 1;107(1):57–61.

53. Manca A, Martinez G, Cugusi L, Dragone D, Mercuro G, Deriu F. Predatory Open Access in Rehabilitation. Arch Phys Med Rehabil. 2017 May;98(5):1051–6.

54. Manca A, Martinez G, Cugusi L, Dragone D, Dvir Z, Deriu F. The surge of predatory open-access in neurosciences and neurology. Neuroscience. 2017 Jun 14;353:166–73.

55. NIH. NIH Public Access Policy | publicaccess.nih.gov [Internet]. [cited 2019 Oct 18]. Available from: https://publicaccess.nih.gov

56. Fraser N, Brierley L, Dey G, Polka JK, Palfy M, Coates JA. Preprinting a pandemic: the role of preprints in the COVID-19 pandemic. bioRxiv. 2020 May 23;2020.05.22.111294.

57. Research N. Author Insights 2015 survey. 2015.

58. Larivière V, Sugimoto CR. Do authors comply when funders enforce open access to research? Vol. 562, Nature. NLM (Medline); 2018. p. 483–6.

59. Michie S, van Stralen MM, West R. The behaviour change wheel: a new method for characterising and designing behaviour change interventions. Implement Sci. 2011 Jan;6(1):42.

60. Morris M. Professors Receive NSF Grant to Develop Training for Recognizing Predatory Publishing. Texas Tech Today. 2019;

61. IDRC grant to improve OA journals from the Global South [Internet]. News, updates & developments from DOAJ. 2016 [cited 2019 Oct 21]. Available from: https://blog.doaj.org/2016/03/22/idrc-grant-to-improve-oa-journals-from-the-global-south/

62. Schroter S, Loder E, Godlee F. Research on peer review and biomedical publication. Vol. 368, The BMJ. BMJ Publishing Group; 2020.

63. Cohen AJ, Patino G, Kamal P, Ndoye M, Tresh A, Mena J, et al. Perspectives From Authors and Editors in the Biomedical Disciplines on Predatory Journals: Survey Study. J Med Internet Res. 2019 Aug 30;21(8):e13769.

64. Fyfe A. 1963: The Royal Society Publishing Code – The Secret History of the Scientific Journal [Internet]. [cited 2019 Oct 29]. Available from: https://arts.st-andrews.ac.uk/philosophicaltransactions/the-royal-society-publishing-code-from-1963/

65. Committee on Publication Ethics: COPE. Code of Conduct and Best PRactice Guidelines for Journal Editors. 2011.

66. Committee on Publication Ethics: COPE. Code of Conduct for Journal Publishers. 2011.

67. Fyfe A. Ownership and control of scientific journals: the view from 1963 [Internet]. THE HISTORY OF THE SCIENTIFIC JOURNAL. The economic, social and cultural history of the world's oldest scientific journal, 1665-2015. 2018 [cited 2019 Oct 8]. Available from: https://arts.st-andrews.ac.uk/philosophicaltransactions/ownership-and-control-of-scientific-journals-the-view-from-1963/

68. Committee on Publication Ethics: COPE. Core practices [Internet]. 2019 [cited 2019 Dec 18]. Available from: https://publicationethics.org/core-practices

69. Teixeira da Silva JA, Tsigaris P. What Value Do Journal Whitelists and Blacklists Have in Academia? J Acad Librariansh. 2018 Oct 22;

70. Bianchini C, Cosentino C, Paci M, Baccini M. Open access physical therapy journals: do predatory journals publish lower quality Randomized Controlled Trials? Arch Phys Med Rehabil. 2020 Jan 28;

71. Yale University. List of Suspicious Journals and Publishers - Choosing a Journal for Publication of an Article [Internet]. Yale University Library Research Guides. [cited 2020 Aug 26]. Available from: https://guides.library.yale.edu/c.php?g=296124&p=1973764

72. University of Missouri. Be wary of predatory journals - Where to Publish Your Research [Internet]. Library Guides at University of Missouri Libraries. [cited 2020 Aug 26]. Available from: https://libraryguides.missouri.edu/WhereToPublish/predatory

73. Trent University. Open Access: Predatory Publishers [Internet]. Trent University Library & Archives. [cited 2020 Aug 26]. Available from: https://www.trentu.ca/library/help/open_access_predatory_journals

74. Teixeira da Silva JA. Caution with the continued use of Jeffrey Beall's "predatory" open access publishing lists. AME Med J. 2017 Jun 7;2:97–97.

75. Beall J. Criteria for Determining Predatory Open-Access Publishers [Internet]. Scholarly Open Access. 2012 [cited 2020 Jan 8]. Available from: https://web.archive.org/web/20120913071030/http://scholarlyoa.com/2012/08/04/criteria-for-determining-predatory-open-access-publishers/

76. Kimotho SG. The storm around Beall's List: a review of issues raised by Beall's critics over his criteria of identifying predatory journals and publishers. African Res Rev. 2019 Apr 16;13(2):1.

77. Olivarez J, Bales S, Sare L, VanDuinkerken W. Format Aside: Applying Beall's Criteria to Assess the Predatory Nature of both OA and Non-OA Library and Information Science Journals. Coll Res Libr. 2018 Jan 1;79(1):52–67.

78. Tsigaris P, Teixeira da Silva JA. Did the Research Faculty at a Small Canadian Business School Publish in "Predatory" Venues? This Depends on the Publishing Blacklist. Publications. 2019 May 20;7(2):35.

79. Beall J. What I learned from predatory publishers. Biochem Medica. 2017 Jun 15;27(2):273–8.

80. Anonymous. Stop Predatory Journals [Internet]. [cited 2019 Oct 18]. Available from:

https://predatoryjournals.com/

81. Anonymous. Beall's List – of Potential Predatory Journals and Publishers [Internet]. [cited 2019 Dec 12]. Available from: https://beallslist.net/

82. Cabell's International. The Black List [Internet]. [cited 2019 Aug 4]. Available from: https://www2.cabells.com/about-blacklist

83. Anderson R. Cabell's Predatory Journal Blacklist: An Updated Review [Internet]. The Scholarly Kitchen. 2019 [cited 2020 Feb 8]. Available from: https://scholarlykitchen.sspnet.org/2019/05/01/cabells-predatory-journal-blacklist-an-updated-review/

84. Pyne D. The rewards of predatory publications at a small business school. Vol. 48, Journal of Scholarly Publishing. University of Toronto Press; 2017. p. 137–60.

85. Stojanovski J, Marušić A. Does small equal predatory? Analysis of publication charges and transparency of editorial policies in Croatian open access journals. Biochem Medica. 2017 Jun 15;27(2):292–9.

86. Broga M, Mijaljica G, Waligora M, Keis A, Marusic A. Publication Ethics in Biomedical Journals from Countries in Central and Eastern Europe. Sci Eng Ethics. 2014 Mar;20(1):99–109.

87. David P. Elsevier Published Fake Journals [Internet]. The Scholarly Kitchen. 2009 [cited 2019 Dec 3]. Available from: https://scholarlykitchen.sspnet.org/2009/05/07/elsevier-published-fake-journals/

88. Grant B. Elsevier published 6 fake journals [Internet]. The Scientist Magazine. 2009 [cited 2020 Feb 3]. Available from: https://www.the-scientist.com/the-nutshell/elsevier-published-6-fake-journals-44160?archived_content=9BmGYHLCH6vLGNdd9YzYFAqV8S3Xw3L5

89. Gowers T. Elsevier — my part in its downfall. Gowers's Weblog. 2012.

90. Jha A. Academic spring: how an angry maths blog sparked a scientific revolution [Internet]. The Guardian. 2012 [cited 2019 Nov 24]. Available from: https://www.theguardian.com/science/2012/apr/09/frustrated-blogpost-boycott-scientific-journals

91. Heyman T, Moors P, Storms G. On the Cost of Knowledge: Evaluating the Boycott against Elsevier. Front Res Metrics Anal. 2016 Oct 17;1.

92. The Cost of Knowledge [Internet]. [cited 2019 Dec 3]. Available from: http://thecostofknowledge.com/

93. Big Deal Cancellation Tracking - SPARC [Internet]. [cited 2019 Dec 3]. Available from: https://sparcopen.org/our-work/big-deal-cancellation-tracking/

94. Olijhoek T, Tennant J. The 'problem' of predatory publishing remains a relatively small one and should not be allowed to defame open access [Internet]. LSE Impact of Social Sciences. 2018 [cited 2020 Feb 2]. Available from: https://blogs.lse.ac.uk/impactofsocialsciences/2018/09/25/the-problem-of-predatory-publishing-remains-a-relatively-small-one-and-should-not-be-allowed-to-defame-open-access/

95. Brienza C. Opening the wrong gate? the academic spring and scholarly publishing in the humanities and social sciences. Publ Res Q. 2012 Sep;28(3):159–71.

96. Van Noorden R. Open access: The true cost of science publishing. Nature. 2013 Mar 27;495(7442):426–9.

97. Monbiot G. Scientific publishing is a rip-off. We fund the research – it should be free. The Guardian. 2018;

98. Amaral OB. All publishers are predatory - some are bigger than others. Vol. 90, Anais da Academia Brasileira de Ciencias. Academia Brasileira de Ciencias; 2018. p. 1643–7.

99. Schira HR, Hurst C. Hype or Real Threat: The Extent of Predatory Journals in Student Bibliographies. Partnersh Can J Libr Inf Pract Res. 2019 Apr 5;14(1).

100. Eriksson S, Helgesson G. Time to stop talking about 'predatory journals'. Learn Publ. 2018 Apr 1;31(2):181–3.

101. Teixeira da Silva JA, Dobránszki J, Tsigaris P, Al-Khatib A. Predatory and exploitative behaviour in academic publishing: An assessment. J Acad Librariansh. 2019 Nov 1;45(6):102071.

102. Cappell MS. List predatory journal publications separately from genuine scholarly publications as standard for CVs. BMJ. 2015;350.

103. Ioannidis JPA, Khoury MJ. Assessing Value in Biomedical Research: The PQRST of Appraisal and Reward. JAMA. 2014 Aug 6;312(5):483.

104. Hedding DW. Payouts push professors towards predatory journals. Nature. 2019 Jan 15;565(7739):267–267.

105. Altbach PG. Paying the professoriate : a global comparison of compensation and contracts. Routledge; 2012. 368 p.

106. Moher D, Bouter L, Kleinert S, Glasziou P, Sham MH, Barbour V, et al. The Hong Kong Principles for Assessing Researchers: Fostering Research Integrity. 2019.

107. Powell K. Does it take too long to publish research? Nature. 2016 Feb;530(7589):148–51.

108. Himmelstein D. The history of publishing delays [Internet]. 2016 [cited 2019 Dec 18]. Available from: https://blog.dhimmel.com/history-of-delays/

109. Committee on Publication Ethics. Discussion document on preprints [Internet]. 2020 [cited 2020 Jun 9]. Available from: https://publicationethics.org/files/u7140/COPE_Preprints_Mar18.pdf

110. Till JE. Predecessors of preprint servers. Learn Publ. 2001 Jan;14(1):7–13.

111. Van Noorden R. The arXiv preprint server hits 1 million articles. Nature. 2014 Dec 30;

112. Okerson AS, O'Donnell JJ, editors. Scholarly Journals at the Crossroads: A Subversive Proposal for Electronic Publishing. An Internet Discussion about Scientific and Scholarly Journals and their Future. Washington, D.C.: Association of Research Libraries; 1995. 1–260 p.

113. Enserink M. Plan for new medical preprint server receives a mixed response. Science (80-). 2017 Sep 12;

114. Tennant J, Bauin S, James S, Kant J. The evolving preprint landscape: Introductory report for the Knowledge Exchange working group on preprints.

115. Ginsparg P. Preprint Déjà Vu. EMBO J. 2016 Dec 15;35(24):2620–5.

116. Bourne PE, Polka JK, Vale RD, Kiley R. Ten simple rules to consider regarding preprint submission. PLOS Comput Biol. 2017 May 4;13(5):e1005473.

117. Kwon D. How swamped preprint servers are blocking bad coronavirus research. Nature. 2020 May 7;581(7807):130–1.

118. Hoy MB. Rise of the Rxivs: How Preprint Servers are Changing the Publishing Process. Med Ref Serv Q. 2020 Jan 2;39(1):84–9.

119. Weber B. Scientists cut peer-review corners under pressure of COVID-19 pandemic [Internet]. CBC News2. 2020 [cited 2020 Aug 6]. Available from: https://www.cbc.ca/news/canada/edmonton/scientists-covid-pandemic-research-misinformation-1.5539997

120. Rabin RC. The Pandemic Claims New Victims: Prestigious Medical Journals [Internet]. The New York Times. 2020 [cited 2020 Jun 28]. Available from: https://www.nytimes.com/2020/06/14/health/virus-journals.html

121. Cobb M. The prehistory of biology preprints: A forgotten experiment from the 1960s. PLOS Biol. 2017 Nov 16;15(11):e2003995.

122. Green D. Death of an experiment. Int Sci Tech. 1967;65:82–88.

123. Marshall E. Franz Ingelfinger's Legacy Shaped Biology Publishing. Science (80-). 1998 Oct 30;282(5390):861–861.

124. Kassirer JP, Angell M. The Internet and the Journal. N Engl J Med. 1995 Jun 22;332(25):1709–10.

125. Polka JK, Penfold NC. Biomedical preprints per month, by source and as a fraction of total literature. Zenodo. 2020 Jul 21;3955154.

126. O'Connell HB. Physicists Thriving with Paperless Publishing. 2000 Jul 13;

127. Larivière V, Sugimoto CR, Macaluso B, Milojević S, Cronin B, Thelwall M. arXiv E-prints and the journal of record: An analysis of roles and relationships. J Assoc Inf Sci Technol. 2014 Jun 1;65(6):1157–69.

128. Serghiou S, Ioannidis JPA. Altmetric Scores, Citations, and Publication of Studies Posted as Preprints. Vol. 319, JAMA - Journal of the American Medical Association. American Medical Association; 2018. p. 402–3.

129. Abdill R, Blekhman R. Tracking the popularity and outcomes of all bioRxiv preprints. bioRxiv. 2019 Apr 2;515643.

130. Luther J. The Stars Are Aligning for Preprints [Internet]. The Scholarly Kitchen. 2017 [cited 2020 Mar 11]. Available from: https://scholarlykitchen.sspnet.org/2017/04/18/stars-aligning-preprints/

131. Kirkham JJ, Penfold N, Murphy F, Boutron I, Ioannidis JPA, Polka JK, et al. A systematic examination of preprint platforms for use in the medical and biomedical sciences setting. bioRxiv. 2020 Apr 28;44(0):2020.04.27.063578.

132. Crossref. Crossref to accept preprints in change to long-standing policy - Crossref [Internet]. 2016 [cited 2020 Mar 10]. Available from: https://www.crossref.org/news/2016-05-05-crossref-to-accept-preprints-in-change-to-long-standing-policy/

133. NIH Preprint Pilot [Internet]. 2020 [cited 2020 Aug 6]. Available from: https://www.ncbi.nlm.nih.gov/pmc/about/nihpreprints/

134. Bornmann L, Schier H, Marx W, Daniel H-D. Is interactive open access publishing able to identify high-impact submissions? A study on the predictive validity of Atmospheric Chemistry and Physics by using percentile rank classes. J Am Soc Inf Sci Technol. 2011 Jan 1;62(1):61–71.

135. Molteni M. Biology's Roiling Debate Over Publishing Research Early [Internet]. WIRED. 2017 [cited 2020 Mar 10]. Available from: https://www.wired.com/story/biologys-roiling-debate-over-publishing-preprint-research-early/

136. More than 5,000 German scientists have published papers in pseudo-scientific journals [Internet]. [cited 2020 Jan 27]. Available from: https://www.ndr.de/der_ndr/presse/More-than-5000-German-scientists-have-published-papers-in-pseudo-scientific-journals,fakescience178.html

137. Shen C, Bjork B-C, Björk B. 'Predatory' open access: a longitudinal study of article volumes and market characteristics. BMC Med. 2015 Dec 1;13(1):230.

138. Moher D, Shamseer L, Cobey KD, Lalu MM, Galipeau J, Avey MT, et al. Stop this waste of people, animals and money. Nature. 2017 Sep 7;549(7670):23–5.

139. Gunsalus CK, Marcus AR, Oransky I. Institutional Research Misconduct Reports Need More Credibility. JAMA. 2018 Apr 3;319(13):1315.

140. Grey A, Avenell A, Klein AA, Gunsalus CK. Check for publication integrity before misconduct. Vol. 577, Nature. Nature Research; 2020. p. 167–9.

141. Manca A, Moher D, Cugusi L, Dvir Z, Deriu F. How predatory journals leak into PubMed. CMAJ. 2018 Sep 4;190(35):E1042–5.

142. Demir SB. Scholarly databases under scrutiny. J Librariansh Inf Sci. 2020 Mar 29;52(1):150–60.

143. Dickersin K. The existence of publication bias and risk factors for its occurrence. Jama. 1990 Mar 9;263(10):1385–9.

144. Song F, Parekh, S, Hooper L, Loke YK, Ryder J, Sutton AJ, et al. Dissemination and publication of research findings: an updated review of related biases. Vol. 14, Health technology assessment (Winchester, England). Prepress Projects Limited; 2010. iii, ix–xi, 1–193.

145. Schmucker C, Schell LK, Portalupi S, Oeller P, Cabrera L, Bassler D, et al. Extent of Non-Publication in Cohorts of Studies Approved by Research Ethics Committees or Included in Trial Registries. Petersen I, editor. PLoS One. 2014 Dec 23;9(12):e114023.

146. Powell-Smith A, Goldacre B. The TrialsTracker: Automated ongoing monitoring of failure to share clinical trial results by all major companies and research institutions. F1000Research. 2016 Nov 3;5:2629.

147. Hopewell S, Clarke M, Stewart L, Tierney J. Time to publication for results of clinical trials. Cochrane Database Syst Rev. 2007;2(2).

148. Dwan K, Gamble C, Williamson PR, Kirkham JJ. Systematic Review of the Empirical Evidence of Study Publication Bias and Outcome Reporting Bias — An Updated Review. PLoS One. 2013;8(7):e66844.

149. Song F, Loke Y, Hooper L. Why Are Medical and Health-Related Studies Not Being

Published? A Systematic Review of Reasons Given by Investigators. Wicherts JM, editor. PLoS One. 2014 Oct 15;9(10):e110418.

150. Hopewell S, McDonald S, Clarke MJ, Egger M. Grey literature in meta-analyses of randomized trials of health care interventions. Cochrane Database Syst Rev. 2007 Apr 18;(2).

151. van Driel ML, De Sutter A, De Maeseneer J, Christiaens T. Searching for unpublished trials in Cochrane reviews may not be worth the effort. J Clin Epidemiol. 2009 Aug 1;62(8):838-844.e3.

152. Korevaar DA, Salameh J, Vali Y, Cohen JF, McInnes MDF, Spijker R, et al. Searching practices and inclusion of unpublished studies in systematic reviews of diagnostic accuracy. Res Synth Methods. 2020 Jan 25;jrsm.1389.

153. National Institutes of Health (NIH). NOT-OD-18-011: Statement on Article Publication Resulting from NIH Funded Research [Internet]. [cited 2018 Jan 15]. Available from: https://grants.nih.gov/grants/guide/notice-files/NOT-OD-18-011.html

154. Abad-García MF. Plagiarism and predatory journals: A threat to scientific integrity. An Pediatría (English Ed. 2019 Jan;90(1):57.e1-57.e8.

155. American Medical Writers Association, European Medical Writers Association, International Society for Medical Publication Professionals. AMWA–EMWA–ISMPP joint position statement on predatory publishing. Curr Med Res Opin. 2019 Sep 2;35(9):1657–8.

156. Hayden JA. Predatory publishing dilutes and distorts evidence in systematic reviews. J Clin Epidemiol. 2020 May;121:117–9.

157. National Science Board NSF. Publication Output: U.S. Trends and International Comparisons. Science and Engineering Indicators 2020. Alexandria, VA; 2020.

158. Brice A, Chalmers I. Medical journal editors and publication bias. Vol. 347, BMJ (Online). British Medical Journal Publishing Group; 2013.

159. McAuley L, Pham B, Tugwell P, Moher D. Does the inclusion of grey literature influence estimates of intervention effectiveness reported in meta-analyses? Lancet. 2000 Oct;356(9237):1228–31.

160. Lalu MM. Personal Communication. 2019.

161. Bryant K. Research from the global south: the important role of context in international research activities. McGill J Educ / Rev des Sci l'éducation McGill. 2014;49(1).

162. Johnson R, Watkinson A, Mabe M. The STM Report An overview of scientific and

scholarly publishing. 5th Edition. The Hague; 2018.

163. Salager-Meyer F. Scientific publishing in developing countries: Challenges for the future. J English Acad Purp. 2008 Apr;7(2):121–32.

164. Swauger S. Open access, power, and privilege: A response to "What I learned from predatory publishing". Coll Res Libr News. 2017 Dec 4;78(11):603.

165. Cash-Gibson L, Rojas-Gualdrón DF, Pericàs JM, Benach J. Inequalities in global health inequalities research: A 50-year bibliometric analysis (1966-2015). Ergin I, editor. PLoS One. 2018 Jan 31;13(1):e0191901.

166. Adcock J, Fottrell E. The North-South information highway: Case studies of publication access among health researchers in resource-poor countries. Glob Health Action. 2008;1(1).

167. Arunachalam S. The Global Research Village: A view from the Periphery Item Type Report.

168. Akre O, Barone-Adesi F, Pettersson A, Pearce N, Merletti F, Richiardi L. Differences in citation rates by country of origin for papers published in top-ranked medical journals: do they reflect inequalities in access to publication? Vol. 65, Journal of epidemiology and community health. BMJ; 2011. p. 119–23.

169. Harris M, Marti J, Watt H, Bhatti Y, Macinko J, Darzi AW. Explicit Bias Toward High-Income-Country Research: A Randomized, Blinded, Crossover Experiment Of English Clinicians. Health Aff. 2017 Nov 1;36(11):1997–2004.

170. Harris M, Macinko J, Jimenez G, Mullachery P. Measuring the bias against low-income country research: An Implicit Association Test. Global Health. 2017 Nov 6;13(1):80.

171. Cochrane Collaboration. PROGRESS-Plus [Internet]. Cochrane Methods Equity. 2017 [cited 2020 Mar 17]. Available from: https://methods.cochrane.org/equity/projects/evidence-equity/progress-plus

172. Demir SB. Predatory journals: Who publishes in them and why? J Informetr. 2018 Nov 1;12(4):1296–311.

173. Søreide K, Winter DC. Global survey of factors influencing choice of surgical journal for manuscript submission. Surgery. 2010 Apr;147(4):475–80.

174. Dallmeier-Tiessen S, Darby R, Goerner B, Hyppoelae J, Igo-Kemenes P, Kahn D, et al. Highlights from the SOAP project survey. What Scientists Think about Open Access Publishing. Arxiv. 2011 Jan 27;1101.5260.

175. Solomon DJ, Björk B-C. Publication fees in open access publishing: Sources of funding and factors influencing choice of journal. J Am Soc Inf Sci Technol. 2012

Jan;63(1):98–107.

176. DeBiasse M. The results are in for the journal selection survey [Internet]. The Molecular Ecologist. 2015 [cited 2020 Feb 21]. Available from: https://www.molecularecologist.com/2015/02/the-results-are-in-for-the-journal-selection-survey/

177. Tenopir C, Dalton E, Fish A, Christian L, Jones M, Smith M. What Motivates Authors of Scholarly Articles? The Importance of Journal Attributes and Potential Audience on Publication Choice. Publications. 2016 Jul 18;4(3):22.

178. Boselli B, Galindo-Rueda F. Drivers and Implications of Scientific Open Access Publishing: Findings from a Pilot OECD International Survey of Scientific Authors. OECD Sci Technol Ind policy Pap. 2016;(33):1–67.

179. Beshyah SA. Authors' selection of target journals and their attitudes to emerging journals: A survey from two developing regions. Sultan Qaboos Univ Med J. 2019 Feb 1;19(1):e51–7.

180. DOAJ. APPLICATIONS: A NOTE ABOUT ARCHIVING AND PRESERVATION. DOAJ Blog. 2015.

181. PMC E. Funders - About - Europe PMC [Internet]. [cited 2020 Jan 24]. Available from: http://europepmc.org/Funders/