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Reporting uncertified science in the news media during the Covid-19 pandemic

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Abstract

Preprints have established a stable position in the dissemination of scientific findings. This position has been reinforced by the Covid-19 pandemic, which required the rapid dissemination of new scientific information. However, in most cases, preprints have not undergone peer review and, as a consequence, lack the scientific rigor of other scientific publications such as journal articles. This presents a challenge for journalists who are tasked with keeping the public informed about the latest scientific developments in the context of great uncertainty during a global pandemic. Having to report on rapidly changing circumstances under increasing pressure from social media while also having to compete for attention in a saturated media landscape might place strain on the adherence to journalistic norms. This does not only have implications in terms of the case-by-case accuracy of reporting, but on the public perception of science at large. This paper investigates the reporting of scientific information from preprints based on a sample of 2,877 online news articles related to Covid-19 in the South African news media. Our results show that despite the publication of guidelines for reporting on preprints in the media, there is still a way to go regarding the judicious use of scientific information from preprints by journalists.

Introduction

The Covid-19 pandemic has had a profound impact on the communication of science – both between scientists, and between science and the public. The formal, internal system of science communication has had to strike a balance between ensuring the reliability of scientific claims about the virus and the rapid communication of claims to accelerate new discoveries to combat the coronavirus.

Preprints have taken on an important role in the rapid dissemination of Covid-19-related science. In fact, one of the biggest disruptions to the certification process in the formal science communication system has been the emergence and institutionalisation of preprints (Chiarelli et al., 2019; Sohrabi et al., 2021). Scientists who are eager and perhaps impatient – sometimes legitimately so – for their findings to be

published post-haste and for scientific information to be shared, are increasingly making their papers available on preprint platforms (ASAPbio, 2020; Sever et al., 2019; Vale, 2015).

The uncertainty surrounding Covid-19 has fueled a torrent of communication activity in the media and on social media as claims and speculations are shared and debated. It is in this context that the provisional science of preprints provides another source of uncertainty. Adding to both the volume and levels of uncertainty are the perverse incentives of the attention economy (Myllylahti, 2020; Nixon, 2020; Tufekci, 2013) driving the spread of misinformation (Carlson and Harris, 2020; Price, 2018; Tufekci, 2013). This creates a challenge for journalists in particular.

On the one hand, they are expected to report objectively to provide the public with factually accurate information (IFJ, 2019). On the other hand, journalists are under pressure from multiple quarters to report more rapidly, more frequently and in ways that attract attention. In such a communication landscape, and given the volume and accessibility of science published in preprint articles, it remains an open question to what extent journalists qualify their reporting of scientific information extracted from preprints. In other words, do they indicate to readers that the information from preprints should be treated with caution and should be read as provisional because the claims in preprints are still subject to review by other scientists? The question also arises whether journalists maintain their professional standards when under pressure to report more rapidly in a context of great uncertainty.

The risk of not reporting responsibly the provisional nature of the claims made in preprint articles is two-fold. First is the risk that journalists fuel the spread of misinformation; second is that journalism may lose its position as a credible observer of and gateway to science (Weingart and Guenther, 2016).

In the context of the Covid-19 pandemic, the following broad question arises in relation to preprints: When uncertified science is communicated in the public sphere, is its provisionality also communicated?

We focus our study on South Africa for reasons related to available research funding but also to relate our findings to similar studies undertaken in other global and national contexts. These studies provide the basis for the further development of our current understanding of preprints as a source of information in the media. Our approach is not only complementary in that it may confirm or contradict the findings of previous studies; it is also complementary in that it adds new dimensions to the study of preprints as sources of scientific information by being platform agnostic, studying journalistic practice in a different national context (i.e. South Africa), by giving consideration to the inclusion of other sources of information in news reports, and by differentiating between types of news articles that mention preprints.

Literature review

Preprints are those publications made available online prior to their formal publication in the form of journal articles (or chapters, proceedings, books and the like). In some cases, pre-prints are post-peer reviewed articles accepted for publication and published online prior to the publication of the final version of the journal article. In the majority of cases, however, pre-prints are articles self-published ‘informally’ by authors without having undergone peer review.

Preprint servers provide the online infrastructure to host preprints on platforms such as SSRN, PeerJ Preprints, Open Science Framework Preprints, arXiv and several discipline-specific arXiv spin-offs such as bioRxiv and ChemRxiv. These pre-print platforms allow for the early registration of scholarly outputs to

support collaborative and networked-based scientific endeavour, and to increase the speed of access and discovery (ASAPbio, 2020; Van de Sompel et al., 2004).

According to recent research by Xie et al. (2021), since the launch of the arXiv preprint server in 1991, the number of preprints has increased exponentially, although they account for only 4% of research articles; preprints are published on average 14 months earlier than research articles; 41% of preprints are ultimately published as a peer-reviewed article; and publications that have been published as preprints attract five times more citations than articles that were not published as a preprint.

It is not that preprints are a new type of publication in the science communication system. What is unprecedented during the Covid-19 pandemic is the volume of preprint articles published (Fraser et al., 2021; Kousha and Thelwall, 2020). According to Fraser et al. (2021), by 20 April 2020, just over a month since the WHO declared Covid-19 a global pandemic, there were more than 5,000 preprints on the topic of Covid-19. Such is the number of preprints published during the Covid-19 pandemic that preprints have attracted the attention of the media (The Economist 2020; Gitlin 2020), and recommendations have been published to guide journalists on how to use preprints in their reporting (Avissar-Whiting, 2020; Hanage and Lipsitch, 2020; Helmuth, 2020; Ordway, 2020a, 2020b; Sheehan and Funk, 2020).

In the face of the Covid-19 pandemic, more intense demands have been placed on science as policy-makers and the public have sought reliable scientific information to inform decision-making and behavioural change. In this situation, the availability of preprint articles has played an important role in advancing scientific discovery and in providing the latest scientific information about the virus to politicians and the public. Pre-prints therefore accelerate and democratise access to scientific knowledge and are therefore a key component in the drive to make science more open (Chiarelli et al., 2019). On the one hand, the global Covid-19 epidemic has been used to validate the importance of open science to increase access to scientific knowledge (see, for example, Unesco, 2020). It is argued that open access and preprint articles enable scientific collaboration on a global scale to accelerate scientific breakthroughs (Maggio et al., 2018) and preprints are likely to remain as important communication format in the formal communication of science (Colavizza, 2021). On the other hand, preprints provide communication mediators such as journalists and, by extension, the public, access to uncertified truth claims.

Journalistic practice is changing with the emergence of digitisation (Fahy and Nisbet, 2011; Guenther, 2019), the introduction of new business models (Bauer et al., 2013), and as a result of a global crisis, in this case, in the shape of the Covid-19 pandemic (Lund and Olsson, 2016; Nord and Strömbäck, 2006). When it comes to reporting on matters related to science, journalists are subject to the pressures of 24-hour news cycles, small (or non-existent) science desks, and the expectation that they capture the attention of audiences in a highly saturated media environment (Guenther, 2019; Myllylahti, 2020; Nixon, 2020). These changes in the media landscape may lead to practices such as ‘strategic reporting’ (Zoizner, 2021), ‘churnalism’ (Johnston and Forde, 2017; Roy, 2017) and ‘horse-race reporting’ (Broh, 1976; Hopmann et al., 2015).

The growth in and value of preprints during the Covid-19 pandemic as a communication form that accelerates the dissemination of scientific findings to make rapid scientific advancements is uncontested (Horbach, 2020). The outcomes of access to uncertified science are, however, not inconsequential (Osman et al., 2018). A recent study found that much of the discussion (and even policy-making) about Covid-19's transmissibility was driven by preprints rather than peer-reviewed literature (Majumder and Mandl 2020). At the same time, there are concerns among scientists about premature media coverage and public sharing

of information before peer review (ASAPBio, 2020). Several cases of inaccurate research related to Covid-19 published in preprints have been reported (Heimstädt, 2020; Marcus and Oransky, 2020). It should also be taken into account that studies have found only a small difference in the quality of preprints and journal articles in the life sciences (Carneiro et al., 2020) and, in cases where preprints are eventually published as journal articles, there is a low degree of difference between the preprint and the subsequent journal article (Polka et al., 2020).

It might be tempting to infer that the growth in preprints can also be attributed to increasing dissatisfaction with the peer review process; a process that can be unreliable and that can slow down the publication process (Nguyen et al., 2015). This claim is, however, not supported by the available evidence. For example, Fraser et al. (2021) found that while there was a rapid increase in Covid-related preprints, there was a similar increase in the publication of Covid-related journal articles. Horbach (2020) found similar increases for both preprints and journal articles. And in a study comprising 14 medical journals, Horbach (2020) found that the journals had accelerated their publication processes; the time between submission and the publication of the journal articles decreased on average by 49%.

To the best of our knowledge, there are two studies that have focused their attention exclusively on the reporting of scientific information from preprints in the media. Fleerackers et al. (2020) focused their study on how Covid-19-related scientific information from preprints were communicated by 15 international digital content providers in developed Anglophone countries. They found hyperlinking common among content providers, but the contextualisation of information broadly lacking. For example, while hyperlinks (to preprints) were often used as citations – marking journalistic credibility – the research cited was less likely to be labelled as preprints. They also analysed the use of what they term 'framing devices' for communicating uncertainty in 100 news stories featuring Covid-19-related preprints and found that approximately half the stories emphasised uncertainty.

Of the total number of articles from the Brazilian media reviewed in their study, Oliviera et al. (2021) found that 38.6% featured attempts to clarify that the findings reported still had to undergo scientific evaluation, while 27.6% failed to do so. A preprint authored by Brazilian scientists on chloroquine as a treatment for Covid-19 stood out as the most commonly referred to preprint. Focusing their framing analysis on this study, Oliviera et al. noticed forms of scientific controversy characterised by politicised and polarised interpretations of scientific findings and journalistic reportage on them.

Theoretical framework

Considering changing scientific and journalistic practices due to the emergence of preprints calls for a closer examination of the emergence and possible persistence of preprints, and of what might be at stake for science and journalism. One approach is to consider exogenous pressures and their impacts on the institutionalised norms of science and journalism.

The co-existence of multiple norms arising from different institutional orders is accounted for by the institutional logics perspective in the theory of organisational institutionalism (Thornton et al., 2012). Logics "refer to the belief systems and related practices that predominate in an organizational field" (Scott, 2001: 139) and are "frames of reference that condition actors' choices for sensemaking, the vocabulary they use to motivate action and their sense of self and identity" (Thornton et al., 2012: 2). The institutional logics perspective therefore accounts for cultural elements – such as values, beliefs and normative expectations –

by which social actors understand, evaluate and organise their decisions and actions (Haveman and Gaultieri, 2017).

Thornton et al. (2012) propose the family, religion, state, market, profession and corporation as the dominant institutional orders in contemporary society. They view these logics as fluid and interactive, arguing that social actors can ascribe to multiple logics, and that different logics can coexist (see also Pallas et al., 2016, on the elasticity of logics). They emphasise that institutional logics are socially constructed, based on a shared, interpersonal understanding of social objects, and are historically contingent with the implication that logics change over time.

Science (Boersema, 2020) and journalism (Lowrey, 2018) are characterised by their adherence to the logic of the profession, although they are not necessarily immune to logics of other institutional orders. In the case of science, the acceptance of preprints in the formal system of science communication aligns with the institutionalized norms shared by the scientific community. By the mid-20th century, sociologist Robert Merton (1973) had proposed four norms (or ideal principles) guiding the social behaviour of scientists: disinterestedness, communalism, universalism and organised scepticism. The norm of communalism dictates that the results and discoveries of science are not the property of the individual researcher but belong to the scientific community and to society at large.

The rise of the information age predicated on digitisation and information communication technologies has seen the discourse around 'openness' as being in opposition to the extractive and restrictive positioning of knowledge as a private good (Boyle, 2003; Chan and Costa, 2005). The opposition is based on the premise that the sharing and reuse of the products of science is less dependent on the services offered by intermediaries such as publishers. Proponents of open science (and, by implication, preprints as a form of open access publication in science) have emerged in opposition to the 'enclosure' of research, or at least to their control by third parties, and advocate instead for their reuse without any undue impediments (Evans, 2005).

Communalism is based on the supposition that the process of knowledge creation is cumulative. In other words, a truth claim, or a new discovery, results not only from individual effort but from the cumulative efforts of a community of scientists. Linked to this imperative is the fact that the individual scientist accumulates no recognition for their truth claim or discovery unless they publish their claim and, in so doing, makes it publicly accessible (Merton, 1968). Preprints as an innovation contributing to open science and as highly accessible publications, are therefore in alignment with the norm of communalism in science.

The inclusion of uncertified science in the formal system of science communication also places greater emphasis on the norm of organised scepticism, that is, scientists' obligation to scrutinise every truth-claim carefully, including their own, suspending final judgement until the necessary confirmations become available. The norm of organised scepticism separates reviewed publications from preprints, and the speed and accessibility of preprints respond to news values and the attention economy. The rise of preprints may reveal a response on the part of some scientists to the attention-seeking imperatives of the media (i.e. the medialization of science). In this context, scientists are required to become ever-more wary of claims made by more dogmatic, unscrupulous and attention-seeking peers (West and Bergstrom, 2021).

In the case of journalism, certain professional norms are shared with science (e.g. disinterestedness). The norm of disinterestedness is exemplified in the South African independent newspapers' code of ethics: "We ensure reporting is impartial and balanced by making every effort to reflect all sides and by maintaining

clear distinctions between comment, conjecture and fact" (Accountable Journalism, n.d.). But there are also norms distinctive to the profession of journalism, including fairness, the right of reply and professional secrecy regarding the source of information obtained in confidence, to name a few. These norms are often codified in policies, codes of ethics and the like (see, e.g., statements and codes of ethics collected by Accountable Journalism [n.d.] and the Global Charter of Ethics for Journalists (IFJ 2019). Several researchers have drawn attention to how journalism has in recent times been subjected to a plurality of norms from politics (Bennet, 1997), the market (Asp, 2014; Lischka, 2020) and technology (Lowrey, 2018; Lischka, 2020).

New forms of scientific communication such as preprints may be aligned with the norms of science, but *may* challenge the norms of journalism, particularly in times of an unprecedented global health crisis. We therefore use the institutional logics framework to explore the possible 'invasion' of other logics and their effects on journalistic practice during the Covid-19 pandemic as it relates to the reporting of scientific information published in preprints in the South African media. We do so by observing how journalists report scientific information from preprints in the news media, and we pose the following specific research questions to operationalise the research: How are pre-prints reported in the South African online news media during the Covid-19 pandemic? To inform this question, five additional, more specific questions are posed: What is the prevalence of reporting on preprint articles in relation to journal articles? Do journalists indicate the provisional nature of the findings published in preprint articles? Are there differences between news media? Do journalists provide hypertext links to the preprint articles? In addition to journalists, who else reports on science from preprints in the news media? Do journalists provide additional views from other sources when reporting on preprint articles?

Methods

Creating a set of news articles that mention preprints

Given the growing importance of online news in South Africa (Newman, 2019), four online news websites were selected for analysis: Health24, TimesLive (TL), Independent Online (IOL), and The Daily Maverick (DM).

In order to familiarise the research team with journalistic practice with regard to preprints, we first searched for news articles mentioning preprints in data from Altmetric. Altmetric is a service that, among other metrics, identifies news articles that mention scientific studies. Querying news mentions of Covid-19-related publications collected by Altmetric and filtering for the news sources in question and the period defined (7 January to 6 July 2020) resulted in 17 accessible news articles mentioning preprints. From those, it became apparent that news articles often did not use the term 'preprint' when referring to the source of the scientific information. This made it clear that it would not be possible to rely on queries using only the term 'preprint' to identify relevant news articles.

We created a second set of online news articles using the Pear Africa media monitoring service. From the Pear Africa data, 22,707 articles were extracted from the same media outlets that contained one or more of the following keywords: corona*; covid*; lockdown. The corpus of articles was again limited to the period 7 January to 6 July 2020. A second filter was then applied to identify only those news reports that referred to scientific articles. This was done by running a search query using the terms 'study', 'studies', 'research', 'preprint', 'pre-print', 'paper', 'publication', 'report'. All articles where the author was indicated

as: ‘afp’, ‘AFP’, ‘AFP Relaxnews’, ‘Reuters’, or ‘Trending’ were removed to include only news articles authored by South African journalists or contributors. Locally syndicated news articles were included as were articles that were likely to have been subjected to “strong editorial filters” (Jaklevic, 2020). This process returned a total of 3,227 news articles (IOL: 330; DM: 1,470; TL: 847; Health24: 580).

Aware that we could not rely solely on filtering the news articles using the term ‘preprint’, the 3,227 news articles were analysed manually for mentions of journal and preprint articles. This was done by conducting a close reading of each article. For the purposes of identifying preprints, a preprint article was defined as any article published online, and which reports findings following a scientific method and according to accepted conventions in terms of how such findings are presented, and which had not been peer reviewed at the time of its publication. This analysis resulted in a further reduction of the data, leaving 2,684 news articles. Out of those, only news articles that mentioned a preprint were used in the subsequent content analysis, i.e. a total of 80 news articles which represents all South African authored news articles mentioning preprints in the four media outlets for the period 7 January to 6 July 2020.

Content analysis

A code book was developed deductively, drawing on published guidelines related to the reporting on preprints (see Table A in the Annexure). Two code groups were identified: (1) provisionality (i.e. the extent to which journalists indicate that the findings reported in preprints are uncertified and therefore provisional); and (2) multiple sources (i.e. the extent to which journalists provide additional information from other expert sources in relation to the preprint findings). The codes for provisionality were as follows: (a) clear statement of provisionality [SP4]; (b) suggestion of provisionality [SP3]; (c) ‘preprint’ or ‘not peer reviewed’ without explanation [SP2]; (d) no provisionality [SP0]; and (e) misunderstanding of preprint or preprint server [SP1]. Sources were coded by type: scientists; scientific article or journal; politician; organisation; medical professional; media; citizens and non-medical professionals; not specified.

The codes were tested by two coders who independently coded the 17 news articles in the Altmetric set. Cohen’s kappa was used to measure intercoder reliability because there were no missing values and no indication of great variance for any single set of codes. A value of .902 was returned using SPSS which indicates a high level of agreement (i.e. almost perfect agreement) between coders (Viera and Garrett, 2005). The news articles for coding were converted from web pages to PDF format and imported into the software package Atlas.ti version 9 (Windows). Two coders independently coded all the news articles in the set. The coders compared their results manually, discussed any variation, and came to an agreement on the final coding for each article. This resulted in a single master set which was used to analyse the results in Atlas.ti and in MSExcel.

Findings

From our initial sample of 3,227 news articles from the online South African news media reporting on Covid-19, a quarter (791, 25%) mentioned journal articles and 4% (123) mentioned preprints. There were 114 mentions of preprints in the analysis sample of 80 online news articles. 46 (58%) of the 80 articles were written by journalists, 11 (14%) by scientists, 3 (4%) by other contributors, and the authors of 20 (25%) of the news articles were unknown.

Table 1 shows that in a minority of articles, there was some form of provisionality provided as a signal to readers to treat the findings with caution: in 5% of cases provisionality was clearly stated, while in 11% it

was merely suggested that the findings from the preprint should be taken as provisional. In 24% of news articles, authors used the term 'preprint' or stated that the scientific article referred to had not been peer reviewed, but provided no explanation to the readers as to what a preprint is or what the implication of describing a scientific article as a preprint is. In the majority of cases (59%), no statement of provisionality was provided, and findings from preprints were often attributed to 'a study' or 'report'.

Table 1: Statements of provisionality in relation to preprints on Covid-19 reported in the South African online news media

Statement type	No.	%	Examples
Clear statement of provisionality	6	5%	"How reliable is this information? The team mentions that their study is a pre-print and has not been peer-reviewed. This means it has yet to be evaluated and should therefore not be used as clinical guidance."
Suggestion of provisionality	12	11%	"suggested that"; "preliminary findings"
'Preprint' or 'not peer reviewed' without explanation	27	24%	"The results were published on a preprint server called ChemRxiv; a preprint study; not yet peer-reviewed"
No provisionality	67	59%	"study"; "report"
Misunderstanding of preprint or preprint server	2	2%	"The new study was published online on the open-data site SSRN"
Total	**114**	**101%***	

* Greater than 100% due to rounding.

We compared the extent to which provisionality was indicated in each of the four media. The Daily Maverick is a news source that publishes more in-depth, investigative news, while the other three sources (IOL, Health24, TimesLive) generally publish shorter, more accessible news. In the case of The Daily Maverick, 40% of preprint references included a clear statement of provisionality, while for the other three news outlets, fewer than one in ten references provided clear statements of provisionality (Health24: 8%; IOL 0%; TimesLive: 9%). The Daily Maverick also showed a relatively high proportion (40%) of references to preprints with no statement of provisionality. For the other three news outlets, the findings were as follows for no statement of provisionality: Health24: 42%; IOL: 100%; TimesLive: 70%.

In the sample of 80 news articles, 233 other sources were mentioned where these sources referred to the preprint findings; an average of two additional sources are included per preprint. Table 2 shows that of the sources referred to, 57% could be described as scientific, i.e. they are either a scientist commenting on the findings from the preprint (30%) or a reference to a scientific article or journal (27%). In 13% of cases, news articles cited comments from a health organisation such as the World Health Organization (WHO) or the Centres for Disease Control (CDC). In 12% of cases, news articles provided less specific information about their sources, referring to them as 'experts', 'researchers', 'studies' or other nonspecific descriptors. Citizens or non-medical professionals (5%), politicians or governments (4%), and medical professionals (3%) were infrequent sources mentioned in news articles reporting on preprints related to Covid-19.

Table 2: Sources cited on the topic of Covid-19 in the South African news media

Source type	No. of mentions	% of mentions
Scientist	69	30%
Scientific article or journal	63	27%
Organisation (e.g. WHO)	31	13%
Not specified (e.g. experts, researchers, a study)	27	12%
Media	15	6%
Citizens or non-medical professional	12	5%
Politician or government	9	4%
Medical professional (e.g. doctor)	7	3%
Totals	**233**	**100%**

News articles were also coded for hyperlinks directing readers to the source of the preprints mentioned (e.g. medRxiv, bioRxiv, etc.). It was found that hyperlinks were provided to 68 (60%) of the 114 preprints mentioned.

Discussion

We found that the proportion of preprints to journal articles appearing in the news media in the case of South Africa is 4%. In other words, despite the exponential increase in the number of Covid-19-related preprints published (Fraser et al., 2021; Torres-Salinas et al., 2021), and confirmation that the news media relies on preprints to a limited degree for their reporting, there appears to be no prominent place for preprints in the media during the pandemic.

On the one hand, this finding could be taken to indicate that the extent of the public's exposure to uncertified science related to the Covid-19 pandemic is relatively low. Consequently, the risk of uncertified science being picked up, misinterpreted and disseminated in other information networks (e.g. social media) may also remain low. And all the more so if, as some research has suggested, the communities of attention for preprints on the social media platform Twitter comprise mostly academics (Carlson and Harris, 2020). On the other hand, it is not only the quantum of news reports that determines whether a report attracts readers' attention; a multitude of other factors also come into play. Carlson and Harris (2020) show, for example, that preprints can run the risk of being mis-used in communication contexts for which they had not originally been intended, although this could be equally true for other forms of science communication.

We found that in 59% of online news media articles no statement of provisionality was provided when reporting on a preprint. This proportion of news articles is higher than found to be the case by Oliviera (2021) – 27% of news in the Brazilian media – and by Fleerackers et al. (2021), who found that in 42.5% of cases news media articles provided no indication that a preprint was a preprint or research. Our finding that in 24% of news articles authors either used the term 'preprint' or stated that the scientific article referred to had not been peer reviewed, but provided no explanation to readers as to what a preprint is or what the implications of non-review are, are consistent with those of Fleerackers et al. (2021: Table 5). This value is, however, much lower than the 52% of news articles that either mentioned peer review or that an article mentioned is a pre-print as reported by Oliviera (2021). Taken together, the two studies and the

study presented in this paper support the notion that journalists are not adhering to norms related to factual reporting and the non-suppression of essential information (IFJ, 2019), nor are they following emerging guidelines specifically related to the reporting of scientific information from preprints. The reasons behind the deviance from professional norms – such as pressures to report rapidly (in contravention of the norm that urgency or immediacy in the dissemination of information shall not take precedence over the verification of facts (IFJ, 2019) – requires further investigation.

In our sample, in a minority of cases a clear statement of provisionality was provided, but none as clear a statement as provided by the preprint servers themselves).[1] Links to preprint articles have the potential to expose readers to additional warnings about the provisionality of preprints (as published on preprint platforms) and to the comments posted by other readers that are often published alongside preprints and provide information cues about the veracity of the findings published in the preprint (Puebla et al. 2021). Our finding that hyperlinks were provided for 68 (60%) of the 114 preprints mentioned is well below the 92% of news articles found to have hyperlinks to preprints in previous research (Fleerackers et al., 2021). However, as Fleerackers et al. (2021) note, their sample may well have been biased towards news media articles containing hyperlinks because of their reliance on Altmetric's method for tracking sources mentioning scientific studies. Nevertheless, our findings further confirm that journalists are not making full use of the affordances of online communication, in this case providing publics with direct access to openly available scientific information.

While limits on news article word counts may preclude overly lengthy explanations of what preprints are and why they should be treated with caution, it would be possible for journalists to make use of the affordances of online reporting to provide hyperlinks to more detailed explanations published elsewhere. We found no instances of such practice by the journalists in our sample. If limited article length and/or the additional time required to source and add hyperlinks are indeed behind the omission of clear statements of provisionality, then it is possible that market logics favouring brevity and speed over maintaining clear distinctions between conjecture and fact, are influencing journalistic practice during the pandemic.

Notable was the fact that our sample also contained news articles written by scientists. The findings show that it is not uncommon for the online news media to invite or commission articles from non-journalists: close to a fifth (18%) of articles were authored either by scientists (14%) or by other contributors (4%). The motivations of scientists for writing in the popular media could be attributed to a decline in science journalists in South Africa (Van Zuydam, 2019), and invitations extended by newspaper editors to scientists to contribute expert information related to the Covid-19 pandemic. It is also possible that scientists contribute to the popular media as a consequence of the growing expectation for them to engage with publics outside of the university or lab (Weingart et al., 2021) or as a consequence of succumbing to the attention-seeking logic of the media (West and Bergstrom, 2021). Again, this could be seen as an intrusion of other logics into science.

Surprising, perhaps, is the finding that news articles authored by scientists showed no significant difference in terms of how preprints were referred to when compared with articles written by journalists. Explanations of what a preprint is or cautions about the provisionality of their findings were equally absent in articles authored by scientists and journalists. To some extent, this should not come as a surprise at all. Unlike the practice of retracting or refusing to publish journal articles that cite articles published in so-called predatory journals (COPE Council, 2019; Frandsen, 2017), the practice of citing preprints in journal

[1] See, for example, the statement on the bioRxiv platform: https://www.biorxiv.org/content/what-unrefereed-preprint

articles is becoming increasingly prevalent and accepted, particularly in some scientific disciplines (Puebla et al., 2021). The institutionalisation of preprints in the formal science communication system may result in scientists assuming that a similar practice of referencing preprints in more popular articles, including those written for the news media, is acceptable practice. If editors and journalists are themselves not more circumspect about preprints, as one might expect them to be, then the practice of scientists referencing preprints but not providing any reason for caution, is unlikely to be proscribed.

The institutionalisation of uncertified science (i.e. preprints) in the formal system of science communication places greater emphasis on the norm of organised scepticism. The same degree of scepticism should operate when referencing preprints in the media. Journalists cannot be expected to execute expert oversight over truth claims published in preprints. They are, however, expected to consult other experts to validate, contextualise or qualify their information sources (IFJ, 2019). In the majority of cases, it was found that news articles provided, on average, the expert opinion of two other sources, where these sources commented directly on the findings published in the preprint. Almost three-quarters of articles included a scientist, scientific article, health organisation or medical professional as additional sources. This finding suggests that while some journalistic norms are being challenged to the extent that they are superseded by norms from other institutional orders, other norms such as verifying the veracity of information (including those published in preprints) are still influencing how journalists report on the pandemic.

In sum, during the first six months of the Covid-19 pandemic, South African journalists relied on science published in preprints, but not necessarily in place of peer reviewed journal articles. Journalists did not, in general, signal the provisional nature of the scientific findings published in preprints when referring to them in their reporting. Nor did journalists always provide links to the openly accessible preprints to provide readers the opportunity for further scrutiny. Journalists did, however, as common practice, consult other experts to comment on the findings reported in preprints. This suggests a complex mix of new, intruding institutional logics and persistence of established journalistic logics that journalists are having to navigate in their reporting of preprints during the Covid-19 pandemic.

Limitations

Two limitations should be noted. First, the analysis relied on a relatively small sample of news media articles mainly due to geographic filtering and the limited period of six months. Second, the six-month timeframe was deemed to be too short to explore any possible change over time in journalistic practice in relation to the reporting of preprints. It is possible that reporting practice will change over time as journalists (and scientists) become more familiar with preprints as a new type of scientific publication, including the benefits and risks of relying on preprints for information.

Conclusion

Preprints are likely to remain a feature in the formal science communication system. The Covid-19 pandemic and the concomitant need for constant updates on the effects and treatment of the virus, as well as the urgent need for rapid advancement in scientific knowledge, has made available to journalists a new source of scientific information.

An increase in scientific publications uncertified by peers and therefore provisional in terms of the validity of their truth claims, raises the risk of their undifferentiated and uncritical use by journalists and, by

extension, by uninformed individuals and even ideologically motivated groups. These relatively new trajectories in the flow of scientific information are a call for caution and for the judicious use of science without compromising the benefits of its openness as has become evident during the Covid-19 pandemic. This will require, amongst others, the responsible reporting of scientific information from preprints by journalists in a context of a reassertion of the institution's professional norms.

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Annexure 1

Table A: Codes derived from the literature on journalistic best practice

Recommendation	Source	Code group	Codes
Journalists should avoid characterizing preprint findings as established facts. make it clear that preprint findings are preliminary.	Ordway (2020a)	**Provisionality (SP)**: Qualification of the scientific information extracted from the preprint by stating the provisional nature of the findings	1. No provisionality 2. Suggestion of provisionality 3. Mentions 'preprint' or 'not peer reviewed' without explanation 4. Clear statement of provisionality 5. Misunderstanding of preprint or preprint server
Where appropriate, help readers understand how the healthcare system works, how science works, how scientific publishing works, how the immune system works, how viruses work.	Helmuth (2020)		
Research has shown that a lack of labeling can lead to reader confusion … sophisticated news consumers, especially when reading online, have difficulty discerning taxonomic distinctions between "report", "investigation", "op-ed" and "opinion"	Iannucci & Adair (2017)		
Readers might not heed caveats about "early" or "preliminary" evidence, Woloshin said. "The problem is, once it gets out into the public it's dangerous because people will assume it's true or reliable, and I don't think that's true." Woloshin suggested news organizations refrain from saying a preprint was "published," which wrongly signals that a manuscript "must have gone through some sort of editorial review."	Jaklevic (2020)		
it would help even more to have solicited and quoted the opinion of at least one independent expert and include any caveats they may have. a make a habit of conferring with researchers. Call other scientists in the same field and ask if they rate the work in the preprint as credible … a journalist should have a group of experts she can go to for advice, while remembering that even experts aren't experts in everything.	Ordway (2020a)	**Other sources (MS)**: Multiple sources of information to confirm, refute, contextualise or question the findings presented	1. Scientist 2. Scientific article or journal 3. Organisation 4. Not specified 5. Media 6. Citizen or non-medical professional 7. Politician or government 8. Medical professional
take time to track down researchers with knowledge and experience in the topic they're covering. When reporting on new health topics such as the Covid-19, which experts worldwide are scrambling to understand, it's a good idea to interview multiple researchers.	Ordway (2020b)		
asking other researchers to comment on the quality of the methodology of the paper can be very informative. give readers a sense of what other papers in the same field have found and whether those conclusions are in line with the preprint findings.	Khamsi (2020)		
it's still up to journalists to do that scrutiny, including reaching out to independent experts and checking to see whether other research concurs.	Jaklevic (2020)		
So that means that as journalists sift through the deluge of preliminary information, they have to take a critical eye to these early reports. Question the researcher, talk to other scientists	Hamilton (2020)		
Seek diverse sources of information. Because no one has digested everything about the state of the epidemic, different experts will know different things and see different holes in our reasoning.	Hanage & Lipsitch (2020)		
journalists find out whether its authors are reputable and have previously done high-quality research	Ordway (2020a, 2020b)	Preprint author information	1. Name(s) of preprint author(s) 2. Institutional affiliation of preprint author(s)

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