

## Reporting COVID-19 preprints: fast science in newspapers in the United States, the United Kingdom and Brazil

Noticiando pré-prints sobre a COVID-19: a ciência rápida em jornais dos Estados Unidos, Reino Unido e Brasil

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**Abstract** *The COVID-19 pandemic accelerated the pace of science. Many scientific data are published on preprint repositories, prior to peer review, which raises questions about the credibility of the information not yet validated by other scientists. We analyzed 76 stories published from January to July 2020 by three newspapers (The New York Times – USA, The Guardian – UK and Folha de S. Paulo – Brazil), having as topic studies on COVID-19 published on preprint platforms. The objective was to analyze how the media covered non-peer-reviewed research, in countries marked by conflicting discourses prompted by the denialist attitude of their government leaders. The results show that the newspapers did not provide a detailed explanation of what a preprint platform is, how the process of publishing research results works, and the implications of a study that has not yet been peer reviewed. The analysis also reveals how these news outlets were guided by the anxiety from an unknown disease, focusing on research on drug trials and seroprevalence. The study leads us to reflect on the challenges and weaknesses of covering fast science and the need to broaden the public's understanding of the methods and processes of science.*

**Key words** *Preprint, Scientific journalism, Scientific communication and diffusion, COVID-19*

**Resumo** *A pandemia COVID-19 acelerou o ritmo da ciência. Muitos dados científicos são publicados em repositórios de pré-print, antes da revisão por pares, o que levanta questionamentos sobre a credibilidade das informações ainda não validadas por outros cientistas. Analisamos 76 matérias publicadas de janeiro a julho de 2020 por três jornais (The New York Times – EUA, The Guardian – Reino Unido e Folha de S. Paulo – Brasil), que tiveram como tema estudos sobre COVID-19 publicados em plataformas de pré-print. O objetivo foi analisar como a mídia cobriu pesquisas não revisadas por pares, em países marcados por discursos conflitantes motivados pelo negacionismo de seus governantes. Os resultados mostram que os jornais não fornecem explicações detalhadas sobre o que é uma plataforma de pré-print, como funciona o processo de publicação de resultados de pesquisas e as implicações de um estudo que ainda não foi revisado por pares. A análise também revela como esses veículos foram guiados pela ansiedade gerada por uma doença desconhecida, com foco em pesquisas sobre testes de medicamentos e soroprevalência. O estudo nos leva a refletir sobre os desafios e fragilidades na cobertura de uma ciência rápida e a necessidade de ampliar a compreensão do público sobre os métodos e processos da ciência.*

**Palavras-chave** *Pré-publicação, Jornalismo científico, Comunicação e divulgação científica, COVID-19*

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## Introduction

### The preprint controversies

On January 31, 2020, nine scientists from the Indian Institute of Technology and the University of Delhi published an article in which they reported an “incredible similarity” between insertions of the SARS-CoV-2 spike protein and the glycoprotein gp 120, present in HIV-1. In their study, the researchers claimed that “the similarity was unlikely to be fortuitous in nature”<sup>1</sup>. With a statement that implied the possibility of an artificial composition of the new coronavirus, it was not long for the “discovery” to be used to support conspiracy theories, such as that the government of China had manufactured the new coronavirus for population control<sup>2</sup>.

The international scientific community criticized the Indian article, pointing to flaws in the methodology and interpretation of the data. In a series of posts on his Twitter account, computational biologist Trevor Bredford of the Fred Hutchinson Cancer Research Center countered what he called the “crazy nCoV2019/HIV conspiracy preprint”<sup>3</sup>. He went on to explain that those short sequences showed matches to a huge variety of organisms, so there was no reason to conclude the similarity with HIV.

On April 17, 2020, researchers at Stanford University School of Medicine and the University of Southern California signed an article estimating that the number of people infected with COVID-19 (Coronavirus Disease 2019) in Santa Clara County, CA, at the beginning of that month, was between 50 and 85 times greater than the 956 cases officially registered up to then<sup>4</sup>. The estimate was based on 3,300 tests, of which 50 showed antibodies against the new coronavirus. On the internet, some conservative commentators interpreted the result as proof that the death rate from the disease was much lower than had been announced, since a large number of people had already been infected and recovered<sup>5</sup>. The argument that COVID-19 was not so serious was exploited, including politically, by the critics of social isolation and business closure measures<sup>5</sup>. Once again, other researchers responded by highlighting the flaws in the study, which included the recruitment of volunteers (via Facebook), the use of a test that had not been approved by the U.S. Food and Drug Administration (FDA) and the possibility of false positive results<sup>6</sup>.

The controversies that link the University of Delhi and Stanford studies have another common

element. Both were published in preprint repositories – open access websites on the internet where authors can publish versions of their articles that have not gone through peer review. This means that the studies had not yet been evaluated by other researchers and published in a scientific journal, a process that can take several weeks or a few months. With the emergence of a global health crisis such as the COVID-19 pandemic, these preprint platforms are at the center of a science dilemma: share data fast in an attempt to contain a disease that spreads quickly, and at the same time guarantee ethical and methodological rigour and the correct interpretation of results<sup>7-10</sup>.

The insertion of preprints in the public debate through the media and beyond academic circles highlights the importance of journalism in science communication<sup>11,12</sup>. In this study, we present the results of a research aimed at investigating how three major newspapers in the United States, the United Kingdom and Brazil reported research on the new coronavirus published in preprint repositories. These countries were selected because they were marked by controversial government administrations regarding the COVID-19 pandemic. The denialist attitude of their respective presidents and prime minister has been criticized by important scientific journals<sup>13-15</sup>. It is important to note that these are strategic nations in their regions and in international geopolitics, which means that actions taken locally have an international impact. Consequently, the media in these places must balance conflicting discourses, reinforcing the need for quality scientific journalism.

### COVID-19 pandemic: time for fast science

The peer-review process was created to systematize the process of proposing, refuting, and validating scientific data. Researchers describe their findings and interpretations in a text and submit it for publication in an appropriate scientific journal. Then, other scientists evaluate the work and point out possible flaws, propose changes or request more data, culminating in the decision to publish it or not. Because it is a rigorous procedure, publication in a renowned scientific journal is a seal of approval for that study. Nevertheless, it does not mean that its content is the final word in science. On the contrary, shared knowledge can and must be continually reviewed and tested, thus ensuring scientific advancement.

Sometimes, the peer-review process can be time-consuming. In normal times, the delay in

publishing a study may not be a major problem. However, how can one deal with such extended deadlines when facing a disease that spreads quickly around the world, causing thousands of deaths? The new coronavirus took its first victims in January 2020 in Wuhan, China<sup>16</sup>, and by the end of October 2021 more than 244 million people in five continents had been infected and almost 5 million had died<sup>17</sup>. Especially in the first months of the crisis, when little was known about the disease, the need for a rapid response to combat the COVID-19 pandemic required sharing data on the pathological agent, the epidemiology of the disease, and possible treatments. Scientific peer-reviewed journals adopted fast tracking measures to speed up publications. In the first three months of 2020, more than 1,000 articles with the term COVID-19 were published on the PubMed platform<sup>18</sup>. On August, a search on the Scopus database recovered 18,799 articles on COVID-19. In addition, the search for new information also made the scientific community, the media, and the general public turn their attention to the fast science of preprints.

The practice of submitting scientific articles for prior review dates back to the 1960s, when the National Institutes of Health (NIH) in Bethesda, Maryland, sent draft manuscripts for consideration by groups of biologists, in an experiment called the Information Exchange Groups (IEGs)<sup>19</sup>. The first initiative for a repository like the current ones appeared in 1991, with arXiv, a non-profit server for physicists at Cornell University, which is still widely used by researchers in the field of exact sciences. In the field of biology, consolidation took a little longer. In 2003, arXiv created a specific section for this area of knowledge, and in 2007 Nature launched a repository that gathered more than 2,000 manuscripts during its five years of existence<sup>20</sup>.

A significant change took place in 2013 with the launch of bioRxiv, by Cold Spring Harbor Laboratory (CSHL), intended exclusively for articles on life sciences research. In the same year, the open-access journal PeerJ also launched its preprint repository for the biological area<sup>21</sup>. Finally, in 2019, CSHL, together with Yale University and The BMJ (British Medical Journal), created medRxiv for researchers in the medical field. In recent years, preprints have also been encouraged within the scope of open science, a movement based on cooperative scientific work and processes, and new ways of diffusing knowledge by using collaborative tools<sup>22</sup>. In January 2020, 117 institutions signed a statement to guar-

antee the free sharing of data and findings of the new coronavirus<sup>23</sup>. Among the commitments was the availability of scientific findings via preprint servers. At the beginning of the pandemic, some newspapers, such as *The New York Times* and *Folha de São Paulo*, followed this trend and removed the paywall of their COVID-19-related content, that is, non-subscribers could access it. In the case of *The Guardian*, all content is already free.

Outbreaks and epidemics in the first decades of the 21st century brought preprint repositories to the forefront. A study by Johansson et al.<sup>7</sup> revealed that between November 2015 and August 2017, there were 174 preprints on Zika, published in four repositories. Between May 2014 and January 2016, 75 preprints on Ebola were found. Although these figures represented an increase in this type of publication at the time, they are nowhere near the exponential increase seen in the COVID-19 pandemic. According to Fraser et al.<sup>24</sup>, in the first four months of the COVID-19 pandemic, the websites bioRxiv and medRxiv alone published 2,527 articles on the topic. Taking into account the 31 repositories analysed by the study, the number of preprints published in this period exceeds 6,000 – 37.5% of the more than 16,000 scientific articles referring to the COVID-19, including the peer-reviewed ones<sup>24</sup>.

In the following sections, we present the methods used to analyse the articles published by three major newspapers in the United States, the United Kingdom and Brazil, as well as the results and reflections from this analysis.

## Material and methods

Despite being caused by the same pathological agent, the COVID-19 pandemic took different paths around the world, with infection and mortality rates that partly reflected the responses taken by each country. In this regard, countries such as the United States, the United Kingdom and Brazil stood out adversely because of their government leaders' denialism of the international health authorities' guidelines for coping with the disease, in particular, the ones related to social isolation and the risk of using drugs that have proven to be ineffective, like the hydroxychloroquine<sup>13-15</sup>. Consequently, in different periods of the crisis, these countries have had the highest worldwide rates of contamination and death<sup>17</sup>. Not by chance, Donald Trump, Boris Johnson and Jair Bolsonaro tested positive for COVID-19, with the British prime minister needing intensive

care. Certainly, these particularities have been reflected in the media coverage, which prompted us to analyze newspapers in these contexts. Within this disputed discursive background, we consider it pertinent to evaluate the treatment given by the media of these specific countries regarding the scientific information not yet peer reviewed.

Newspapers make up the so-called traditional or legacy media<sup>25</sup>. We turned to this type of outlet for its track record of credibility and its resurgence as a reliable source of information during the COVID-19 pandemic<sup>25</sup>, especially in its online versions<sup>26</sup>. As our objective was to analyse important newspapers from those countries, well known nationally or internationally, we looked for what the scholarly literature designates as “elite newspapers”, defined as commercial news organizations with a large circulation, which enjoy a consolidated reputation<sup>27</sup>. Furthermore, studies show that these newspapers are able to place certain subjects in the public debate, acting as agenda-setters for other outlets<sup>27</sup>. Finally, elite newspapers are more likely to present balanced coverage of an issue<sup>28</sup>. Considering these premises, we selected the newspapers *The New York Times* (USA), *The Guardian* (UK) and *Folha de São Paulo* (Brazil) – centenary organizations with wide circulation and which make all their content available on the web.

We defined the collection period as the first half of 2020. This is because, in the early phase of the health emergency, preprints were a widely used alternative to share scientific information about the new coronavirus. For example, of all COVID-19 preprints published by bioRxiv and medRxiv from January 2020 to October 2021, 30% were brought out in the first six months of 2020 (5,957 out of 19,039). From 1 January to 30 June 2020, we searched directly in the newspapers’ websites using the keywords: *preprint* (in English and Portuguese, in addition to their possible variations), *bioRxiv*, *medRxiv* and *arXiv*. The results identified 76 stories – 30 from *The New York Times*, 20 from *The Guardian*, and 26 from *Folha de S. Paulo*. It is important to highlight that the 76 stories analyzed in this paper correspond to all the publications of the three newspapers with references to preprint studies (not a sample selection).

In a deductive approach, all the material was read and coded according to previously defined categories, related to the theme of the preprint, the way the newspaper treated it, and the presence or absence of elements that would provide the reader with a better understanding of the na-

ture, scope and limitations of this type of study. The coding was performed manually using Excel.

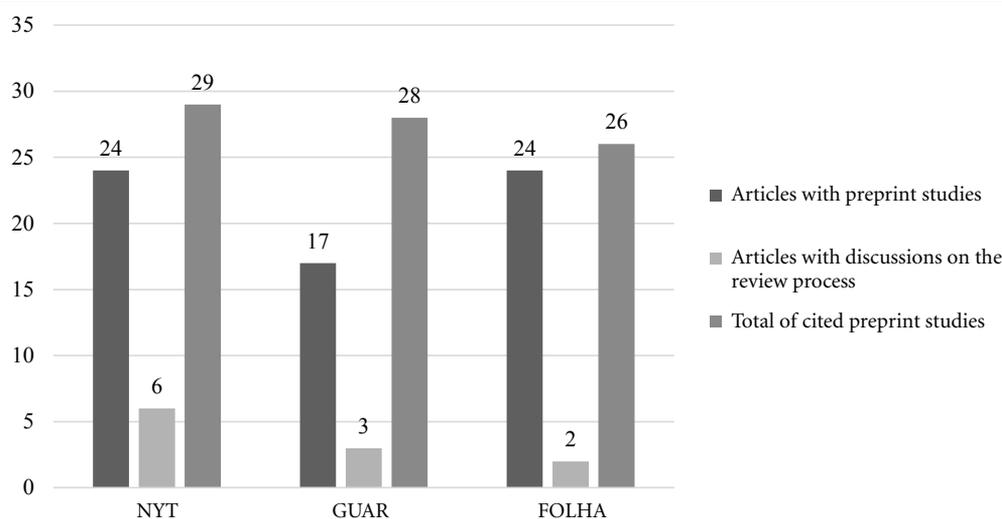
## Results

The first reports on a “mysterious illness” were published a few days after the Municipal Health Commission of Wuhan, in Hubei province, China, reported to the World Health Organisation (WHO) more than 40 cases of a pneumonia of unknown origin at the end of December 2019<sup>16</sup>. The escalation of the disease in the following months was the object of intense media coverage around the world. Altogether, between January and June 2020, *The New York Times*, *The Guardian* and *Folha de S. Paulo* published 35,850 articles on the new coronavirus. Of the total, 76 articles addressed studies published on preprint platforms, which represents 0.2% of that total.

Of the 76 articles, 65 focused on the research results. Altogether, the newspapers cited 83 studies that had not yet been peer reviewed at the time of publication. On the other hand, 11 articles did not report on specific research, but raised discussions and debates about the process of publishing a scientific article and the practice of disseminating preliminary versions of a study. Although *The New York Times* published more stories, the numbers balanced out among the three newspapers (Figure 1).

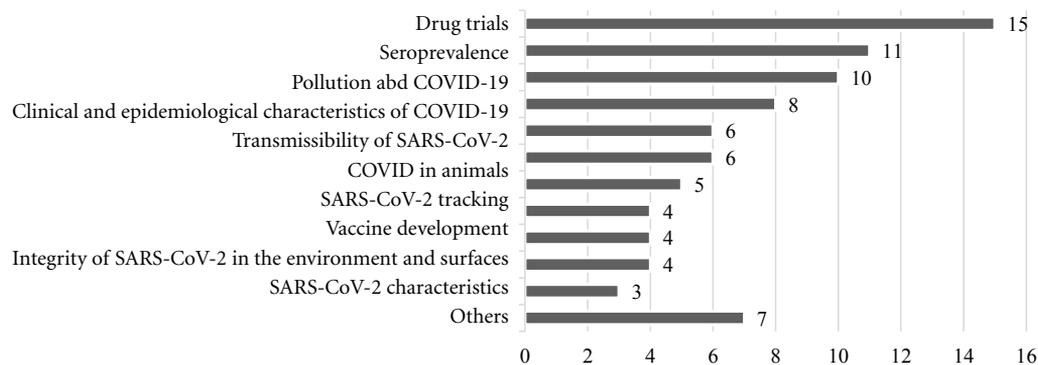
Of the 65 articles published on preprint studies, almost half (n = 31) mainly focused on the results of the research. The other 34 articles used the preprint studies as sources of data or complementary information. *The Guardian* had a slight predominance of articles where the study was the main story.

The 83 citations on preprint studies addressed a wide variety of topics. We identified 16 research areas, most prominent among them *drug trials* (15 citations), *seroprevalence* (11), and *pollution and COVID-19* (10) (Figure 2). However, each newspaper differed in terms of which research was most often covered. *The New York Times* and *The Guardian* have more similarities (*drug trials* and *seroprevalence*), while in *Folha de S. Paulo* studies on *integrity of SARS-CoV-2 in the environment and surfaces* and *clinical and epidemiological characteristics of COVID-19* received more attention. In general, they are studies related to the most basic characteristics of a disease and a virus that need to be quickly understood and treated. Most of these studies (n = 58) provided a direct hyperlink to the publication. This



**Figure 1.** Articles on preprints, articles with discussions on the review process, and numbers of cited preprint studies (Jan-Jun/2020).

Source: Authors.



**Figure 2.** Topics of the cited preprints in the three newspapers (n = 83).

Source: Authors.

trend was less frequent in the Brazilian newspaper, where half of the studies had a hyperlink, and the other half did not (Figure 3).

It is important to note that nine of the 15 citations on the search for possible drugs to treat COVID-19 referred to chloroquine and hydroxychloroquine, drugs originally used in the treatment of malaria and whose effectiveness against the new disease has not been proven<sup>29</sup>. *The Guardian* had more references on this topic.

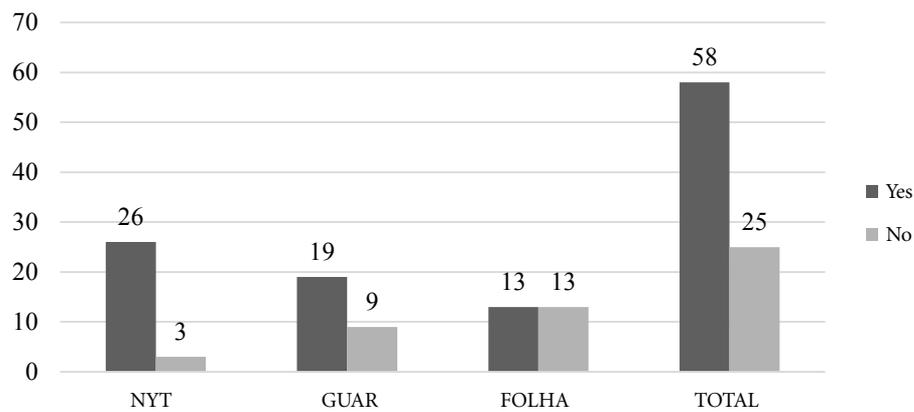
We also identified whether articles that cited a preprint mentioned the platform on which it

had been published. The result shows that of the 83 references to these works, half (n = 42) did not have this information in the body of the article. This was most noticeable in *The Guardian* and *The New York Times*. On the other hand, the name of the repository appeared frequently in *Folha de S. Paulo*. The most cited were medRxiv (n = 27) and bioRxiv (n = 11). Studies deposited at Cambridge Open Engage, Harvard's DASH and the preprint section of *The Medical Journal of Australia*, appeared only once in each newspaper.

Another aspect was whether newspapers explained the meaning of preprint and what a preprint repository is. Of the 65 articles referring to research results published as preprint, 50 (77%) provide some explanation of the term, with *The New York Times* proportionately providing the reader with the most information (Figure 4). However, it is important to note that in almost all articles that explained the term (90%) they did so only briefly. Most of the time, the article only said that a preprint article “has not yet been peer reviewed”, without explaining the impact of this on the validation of the results. Finally, in five of the articles there was no explanation of what the term means.

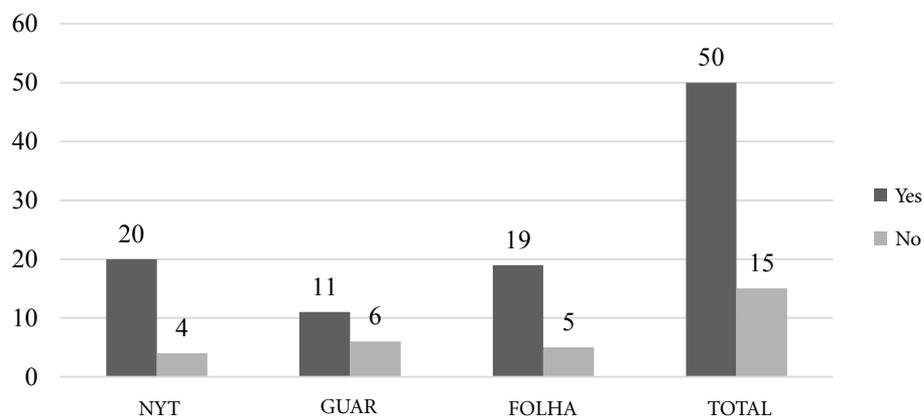
As to the repositories, we found the opposite result: of the 41 times they were mentioned, only 11 (27%) included an explanation of what these websites are and how they work. Once again, the clarification was brief, and was limited to saying that it is “an online platform for scientific articles”. In *The Guardian*, the explanation appeared only once, and in *Folha de S. Paulo*, twice. Whereas in the North American newspaper, of the 13 times a preprint platform was cited, eight are explained.

Regarding the description of the research in the stories, we identified references to the methodology and the responsible researcher and/or their institution. As for the first aspect, 56 of the



**Figure 3.** Direct hyperlink to the preprint (n = 83).

Source: Authors.



**Figure 4.** Explanation of the term “preprint” (n = 65).

Source: Authors.

83 cited studies (67.5%) mentioned the methodology, albeit briefly (e.g. indication of the number of participants in an experiment, the dosage of a medication, type of analysis). This was proportionately lower in the British newspaper, characterized by stories that cited several studies, but in a brief way.

Lastly, most articles (59%) cited the preprint without additional statements or interviews with at least one of the authors of the research (Figure 5). The result differed in the North American newspaper, which collected statements from researchers from 18 of the 29 articles reported (62%). *The Guardian* interviewed the authors of only 6 of the 28 preprints published in their stories (21.4%).

Contrary to the previous data, in 57 articles reported (68.7%) the newspaper interviewed other researchers who were not part of the study. Apparently, newspapers looked for comments on the preprint results from local sources in their respective countries. *The New York Times* had the highest rate of interviews with other scientists.

## Discussion

The results show that preprints occupied a small portion in a sea of information – only 0.2% of all articles on the new coronavirus published in the first half of 2020 by *The New York Times*, *The Guardian* and *Folha de S. Paulo*. However, this percentage should not be considered in absolute terms. In the current context of a hybrid

media system<sup>30</sup>, a single news story can gain great traction on other platforms and reach the irrepressible territory of social media. Fraser et al.<sup>24</sup> observed, for example, that between January and April 2020 the 10 preprints on COVID-19 most reported by the press appeared in more than 120 news stories. In the same period, five of them were also the most shared on Twitter.

The topics most covered reveal how the criteria for newsworthy articles in the newspapers were guided by the anxiety resulting from the pandemic: the search for treatment (*drug trials*) and the identification of antibodies against the virus in the population (*seroprevalence*). The latter is important for the understanding of the immune system's response to the disease, for a realistic projection of the number of people infected, and for the development of tests and vaccines (the third topic with the most cited preprints – *pollution and COVID-19* – can be considered an outlier, since only one article from *The Guardian* cited eight research on this subject). This trend was less pronounced in the Brazilian newspaper. Still, it is possible to note the newspaper's concern with addressing the general characteristics of a new disease and virus.

However, the greater frequency of articles based on the research of chloroquine and hydroxychloroquine makes the discussion about fast science (reviewed or not) more complex. The first results on the use of these drugs against COVID-19 were published precisely in peer-reviewed journals<sup>31,32</sup>. Due to these studies, the then president of the United States, Donald Trump,

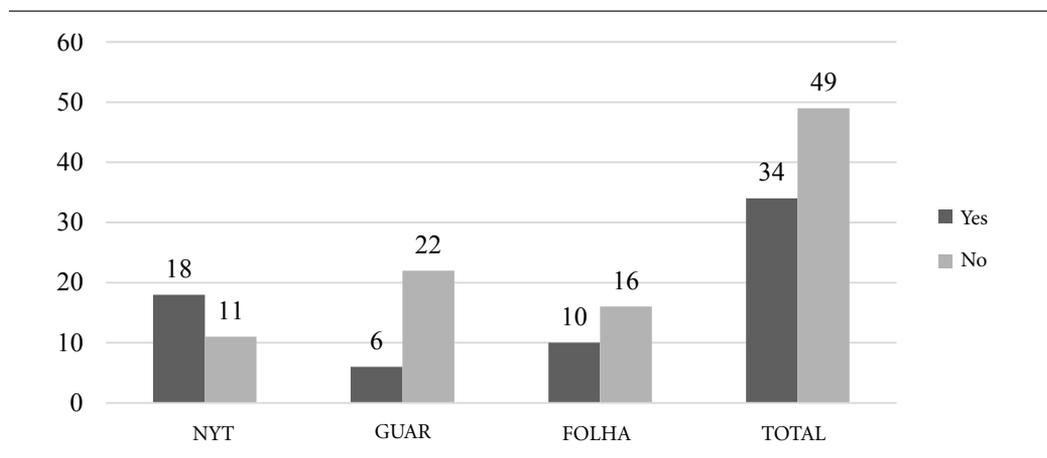


Figure 5. Statements or interviews with the authors of the study (n = 83).

and the president of Brazil, Jair Bolsonaro, publicly supported the use of hydroxychloroquine as an effective treatment and as a guarantee for reopening the economic activities, contrary to the guidance of their own health advisers. In Brazil, the lack of alignment in the protocols led to the resignation of two Ministers of Health.

The issue became even more blurred when a study published in May in *The Lancet*, which claimed to have analyzed data from more than 96,000 patients from different countries and concluded that hydroxychloroquine was ineffective, received a disclaimer from its authors<sup>33</sup>. The results of the analysis, which substantiated the WHO's decision to suspend research on the drug worldwide<sup>34</sup>, were questioned based on the weakness in the data provided by the company Surgisphere<sup>35</sup>. Subsequently, a series of studies determined the ineffectiveness and risks of using hydroxychloroquine to treat COVID-19<sup>29</sup>.

In this case, the three newspapers disseminated the controversies evenly. In a detailed address on the topic, *The Guardian's* article "Hydroxychloroquine and coronavirus: a guide to the scientific studies so far", listed the main research on the subject that had been published both in peer-reviewed journals and in preprint repositories, pointing out the results and limitations<sup>36</sup>. The three newspapers also disseminated a preprint by Brazilian scientists, reporting that the research using chloroquine in 81 patients had been suspended after high doses of the drug were associated with the risk of severe arrhythmias that could lead to death.

Oliveira et al.<sup>37</sup> also identified attention to the hydroxychloroquine controversy. The authors found that a single preprint article on this subject was mentioned in 231 stories from 164 news outlets across countries. In Brazil – the context in which the study was carried out – this preprint was cited in 16 articles from seven outlets. In analyzing these stories, the authors noted that the emphasis on the political crisis, centered on the Brazilian president, was the most frequent framing.

When covering fast science, our figures show that, in general, little attention is given when handling information related to preliminary articles. Hence, the reader ends up without a detailed explanation of what a preprint platform is, how the process of publishing research results works, and the implications of a study that has not yet been under the scrutiny of other researchers. Our results are in line with other studies focused on media coverage of studies without peer review. By analyzing 521 references to preprints cited

by English-language news outlets between January and April 2020, Fleerackers and colleagues<sup>38</sup> found that 57.5% of the stories made use of one or more framing devices to emphasize the scientific uncertainty of the preliminary studies they were reporting (i.e., they mentioned that the study was a preprint, unreviewed, preliminary, and/or in need of verification). However, of those who framed the preprint as uncertain, most included just a single statement that the research had not been peer reviewed. Furthermore, over 40% of stories did not make this clarification. The authors reflect on whether outlets' tendency to refer to this type of study as "research" rather than "preprint" might be a strategy to maintain credibility or avoid alienating readers with limited knowledge of scientific methods.

In a similar pattern, in the study in Brazilian outlets<sup>37</sup>, mentioned above, more detailed information about the preliminary nature of preprints was found in 38.6% of the corpus, comprising 453 news stories. However, the authors noted that in 27.2% of the stories there was no explanation at all; in 13%, the explanation was superficial; in 6.6%, the explanation was wrong.

Although our results show that almost 70% of the cited studies include a direct hyperlink to the repository where they are published, this does not guarantee necessarily that the reader will consult the primary source, nor does it exempt the newspaper from making the necessary clarifications in the body of the article. The lack of hyperlink contextualization in news stories is also problematized by Fleerackers et al.<sup>38</sup>, who found even greater use of this feature in their study: over 90% of the stories they analyzed included a hyperlink to at least one preprint.

It is worth mentioning that in the current pandemic, the repositories themselves took precautions regarding data and preliminary findings. On the medRxiv and bioRxiv websites, a highlighted banner warns the readers of the limitations of published works to ensure they are not used to guide clinical practices and health-related behaviors, and that they are not reported in the media as consolidated information. *The New York Times*, *The Guardian* and *Folha de S. Paulo* address these issues satisfactorily, including the definition of concepts and the opinion of researchers regarding the time and processes of science, but they do so only occasionally and in a very small number of articles.

From the point of view of science communication, this occasional approach is aggravated by the fact that we did not verify in our corpus

the practice of newspapers to return to studies previously reported, at least not within the selected period. This means that, even though the articles explain that the study was not reviewed, its future confirmation (or not) apparently is not followed up, although future research may attest to this perception. The risk is for the journalist to be guided only by newsworthy, favoring immediate and exaggeratedly promising or sensational headlines with the aim of provoking emotional stimulation<sup>39</sup>. Also, because there is no guarantee that a preprint will ever be published in a scientific journal. For example, during the first five months of the COVID-19 pandemic, Gianola et al.<sup>40</sup> found that only 8.6% of preprint articles were then published as peer-reviewed publications. Add to that context the increase in the amount of work in an area with already precarious working conditions for many journalists<sup>41</sup>.

As to reporting the results of the research, there was an attempt, albeit brief, to explain the methodological procedures adopted by the scientists. However, this was more frequent in the articles whose focus was on the study, and not when citing it marginally. In addition, some of the articles untie the study from its sources – either in relation to the institution or authorship, or when the newspaper does not directly interview the researchers in charge of the study (*The New York Times* was an exception in this case). Although this is “compensated” by consulting secondary sources, taken together, the data demonstrate the limitations of a science coverage that albeit fast, becomes incomplete and displaced from the context in which it was produced.

### Final considerations

The analysis of the 76 articles (and the 83 studies cited) published by *The New York Times*, *The Guardian* and *Folha de S. Paulo* during the first six months of the COVID-19 pandemic demonstrates that when dealing with a health emergency, preprints enable science time to catch up with journalism time. Faced with the threat of a new disease, the practice of publishing data and preliminary results can be considered a contributing factor towards the search for fast answers, and as a source of guidance for the population and health authorities<sup>8,9</sup>.

The study also demonstrated how the preliminary nature of preprints and their consequent limitations were minimized in most news articles published in the first six months of the health

emergency by newspapers in the United States, the United Kingdom, and Brazil. This led to our conclusion that, intentionally or not, journalists do not tend to pay special attention or exercise more care in covering studies that were not peer reviewed. Pointing out the reasons for this practice requires further investigations. For now, we align with concerns raised by other researchers about how the results of scientific work are being disseminated via the media<sup>37</sup>, in addition to questioning whether the media avoids delving into the uncertainty of preprints as a strategy to maintain its credibility<sup>38</sup>.

Undoubtedly, the COVID-19 pandemic is an unprecedented challenge for science communication. Science journalism is a specialized area, which demands professionals with specific knowledge and time to read articles, understand extremely technical information, examine and check. But none of this seems to follow the pace of digital communication, sometimes resulting in superficial and incomplete handling of the news. As Fleerackers and colleagues<sup>38</sup> argue, outlets do not appear to consistently follow public health risk communication best practices when it comes to the portrayal of uncertainty surrounding COVID-19 preprint research.

Collaboration needs to be mutual<sup>11</sup>. Although only occasionally, we identified instances in the corpus that show how this is possible. For example, the articles “How you should read coronavirus studies, or any science paper” and “How *The New York Times* reporters handle scientific studies”, in which *The New York Times* explains the process of publishing articles and the procedures adopted by the newspaper when covering science<sup>42,43</sup>. The same is true for the article “How science works (and what are the risks of preprints in the pandemic)”, published by *Folha de S. Paulo*<sup>44</sup>.

It is important to remember that even before the COVID-19 pandemic, the scientific world was already moving towards improving its processes, making them more transparent and democratic<sup>20,45</sup>. One of the alternatives has been to create systems for pre-reviewing articles, in which researchers volunteer to evaluate and comment on preprints<sup>8,46,47</sup>. Among the initiatives are Review Commons (EMBO and ASAPbio), Sinai Immunology Review Project and Outbreak Science Rapid PREview. Recently, medRxiv and bioRxiv have also taken steps to avoid publishing poor quality articles. To publish a preprint, authors need to consent to a series of statements regarding plagiarism, registration of clinical trials, ethical issues, funding, and availability of data.

These changes, both in science and in science communication will allow us to provide responses that are more effective to the challenges imposed by COVID-19 and other health emergencies. Only then, will we be able to make not only fast science, but also a better science.

### **Collaborations**

Both authors participated in all the steps of the paper, including the conception of the study, the methodology design, the analysis and the writing.

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