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Pro-Metrics

REVIEW ARTICLE

# Impact of the COVID-19 pandemic on scientific communication: A review

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**ABSTRACT**

**Objective.** The impact of the COVID-19 pandemic on scientific communication was analyzed.

**Design/Methodology/Approach.** A literature review was conducted based on studies indexed in the Scopus, Web of Science, Proquest, and Pubmed databases. The temporal coverage was from 2020 to 2024. Descriptors and keywords related to the topic in question, as well as inclusion and exclusion criteria, were used to select the relevant literature.

**Results/Discussion.** The COVID-19 crisis revealed the vulnerability of the scientific system, especially the development of preprints, fake studies, and retractions. All this exacerbated misinformation and undermined public confidence. The proliferation of fake news and conspiracy theories complicated the task of scientists and policymakers to report effectively.

**Conclusions.** Despite these challenges, science communication gained relevance with the increased use of digital platforms and social networks for faster and wider dissemination, reflecting a growing public demand for transparency and accuracy in the information disseminated.

**Keywords:** science communication; COVID-19; misinformation; science popularization; public understanding of science; fake science.

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## 1. INTRODUCTION

Science is society's most important social instance to produce accurate knowledge. Therefore, scientific communication is considered highly relevant, especially when there is uncertainty in cases of emergency. In early 2020, the health crisis caused by the COVID-19 pandemic unleashed an urgent demand for information and scientific advice to prevent the spread of the virus. The research output related to COVID-19 is unprecedented. This was due to the large number of studies developed, which were highly subjected to public scrutiny (Lobera & Torres, 2021).

Academic databases began to provide open access to their contents on the subject. This influenced the dissemination and socialization of knowledge, which was of great benefit to health institutions and research centers, whose interest was to find a solution for the containment of the virus, the treatment of the disease, or the generation of a vaccine (Ganga *et al.,* 2020; Artigas *et al.,* 2021).

In 2019, the existence of fake news and its impact on science communication was alerted as a serious problem. This is called fake science, which has been related to the increase of false scientific information (López & Ollé, 2019). In 2020, after the start of the COVID-19 pandemic, the World Health Organization (WHO), in addition to the aspects related to the non-spreading of the virus, warned about a possible infodemic or information epidemic. This referred to the existence of a large amount of information that, difficult to process, was largely false. Scientific infodemics are generated because part of this disinformation present in social media refers to scientific content, either about the origin of the virus, its cure, and prevention, as well as the production of vaccines (López & Ollé, 2020).

According to Jourovála (2020), the health crisis generated by COVID-19 is just a reminder of the major drawback of existing misinformation as well as digital falsehoods. Digital platforms are used as the main instrument for disinformation and reader fraud. Rivas & Calero (2020) point out that it is undeniable that attention should be paid to the evaluation of the possible causes that affect the dissemination of scientific content and its dissemination effects.

There are now countless studies associated with COVID-19. Many of these articles were published in real-time. The most prestigious journals worldwide published studies almost daily using the continuous publication model. However, many articles were published in open-access repositories as *preprints,* that is, prior to peer review (Beldarrain, 2020). This form of publication in *preprints* increased during the Covid-19 emergency. It should be noted that, through this route, the publication process does not comply with the conventional mechanism of anonymous peer review.

One disadvantage of preprints is that they harbor incorrect information or results. This may encourage erroneous practices in patient treatment (Enserink, 2017). However, it has also been found that in some cases, the quality of the content of preprints does not differ significantly from the final publications. Certainly, preprints fostered open science and support for the challenges posed by the emergency imposed by COVID-19 (Brainar, 2020).

The rapid spread of this virus around the world directly impacted science communication. That is why, in this study, we will analyze the impact of COVID-19 on science communication. Our aim is to systematize the most significant approaches present in the literature. Throughout the article, we seek to answer the following research questions:

- Research question 1: What is the published scientific literature on the impact of Covid-19 on science communication?
- Research question 2: What are the aspects that, during the COVID-19 pandemic, have impacted scientific communication?

## 2. LITERATURE REVIEW

### 2.1. Peer review speed, use of preprints, and impact on citation metrics

Peer review involves the critical evaluation of manuscripts by experts who generally do not belong to the editorial team of the journal in question. This evaluation, which must be impartial, independent, and critical, is essential in the academic process. It is indisputable that peer review is a fundamental part of the scientific process. With the emergence of the pandemic

and, in order to avoid long turnaround times in publication, authors resorted to the use of preprint servers (Párraga, 2021). It was a fact that the increase in the speed of dissemination of new scientific studies on COVID-19 led to the need to reduce reaction times in the publication process and practices (Meri-Yilan, 2023). Findings from certain studies indicate that publication times decreased since the pandemic's onset. Journals reduced the length of the editing process by almost 50% from the average. It was sometimes reduced to more than 80% (Horbach, 2020).

The *preprints* allowed accelerated publication of the findings through servers such as bioRxiv and medRxiv. It should be noted that in these cases, traditional editorial validation and peer review did not take place. During the pandemic, many journals and publishers set up collection centers on their web pages to collect material related to the virus. Among the most important were the multidisciplinary journals Nature and Science and the medical journals New England Journal of Medicine, JAMA, BMJ, and The Lancet, as well as the databases of publishers such as Elsevier, Springer, Oxford, and Wiley (Mheidly & Fares, 2020). Preprints filled important gaps in the scientific publication process. They were also important in meeting the need for open access to science and in supporting the scientific response to the challenges posed by the pandemic. Their role in fostering supportive and collaborative support was also highlighted, something unprecedented in the field of health and health systems (Hernandez, 2020).

According to Rivera & Palomino (2024), the greatest scientific production on Covid-19 took place in US universities, most notably Harvard and New York. Citations also skyrocketed, as happened to the journals Stroke and Journal Stroke and Cerebrovascular Diseases. In addition, more citations per publication were observed at the institutional and international levels, with an average of 34.9 and 33.4, respectively. The subject areas with the highest number of studies were Neurology, Cardiovascular Medicine, and Cardiology.

Galvez's (2023) study showed that the most cited research on COVID-19 was *"Telehealth transformation: Covid-19 and the rise of virtual care",* a study that addressed the significant transformation of telehealth and telemedicine during the pandemic. This paper was cited 392 times, with an average of 130,667 citations per year. Another notable study, "Covid-19 Transforms Health Care through Telemedicine: Evidence from the Field," examined the momentum and change in telemedicine in health care. This article obtained 335 citations and an annual average of 111,667 citations. Similarly, Liu *et al.,* (2023) state that more than 8% of COVID-19 articles published in 2020 and 2021 were classified as highly cited articles according to the Essential Science Indicators, far exceeding the global benchmark of 1%.

### 2.2. Focus on collaboration

The pandemic imposed an urgent international coordination among researchers and institutions to obtain answers and solutions to combat the virus. This included the creation of a study, research, and innovation agenda to develop scientific knowledge within the framework of strict containment (Garcia *et al.,* 2024). WHO convened more than 300 specialists and funding entities from different countries within this framework. Planning was established that gave priority to research and innovations related to the virus (WHO, 2020a). The scientific community also established the Global Health Network in January 2020 as a community of practice to address the study of COVID-19 in low- and middle-income countries (Feune *et al.,* 2020).

Indeed, the crisis generated by Covid-19 prompted countries with high-income levels to generate a high level of scientific production in order to achieve health solutions and control the virus and its rise. However, a lower level of scientific production was generated in low-income countries, including most Latin American countries (WHO, 2020b). In other words, when the pandemic was declared, the formation of different collaborative groups in different countries of the world began to grow exponentially, varying in composition as well as in the way scientific information was generated and disseminated. Experts in different areas came together with a common objective: to generate knowledge and share experiences to counteract the virus (Fernández & Alfonso, 2021).

During the first two years of the pandemic, collaborations between high-income countries and low- and middle-income countries enabled a rapid scientific response to the public health emergency, despite geopolitical tensions. Collaborative research among these countries addressed relevant public health needs, as was the case in the United States, China, the United Kingdom, and India. Likewise, co-authorship relationships between high-income and low- and middle-income countries were more balanced, with research interests aligned with national and global expertise (Carvalho *et al.,* 2023).

### 2.3. Importance of clear communication and open access

During the Covid-19 health crisis, many scientific publishers decided to grant open access without limitations to anyone. This was an unprecedented event, causing open access to science to become a topic of discussion (Robinson & Jimenez, 2023). With the justification of sharing information and helping to achieve faster solutions, the health emergency situation caused open access to take on great importance in the context of scientific communication and open science (Martínez, 2021). Certainly, there was a notable increase in the number of open-access publications during the pandemic, although this increase was not comparable to that of publications under restriction. Furthermore, there was no indication that open-access articles gained more popularity. Therefore, a shift toward open access was not observed during this pandemic period (Nane *et al.,* 2023).

### 2.4. Use of digital media

During the pandemic, an avalanche of information was generated, making it essential to use a dedicated platform for everything related to the virus. This was the case for the Indian government, which implemented a web portal for this purpose, as well as a national and state helpline, an email, and a government social hub via WhatsApp, Twitter, Facebook, New Desk, Telegram, Instagram, Twitter, LinkedIn and YouTube. It also developed the *Aarogya Setu* mobile application to proactively inform users about risks and relevant news (Reddy & Gupta, 2020).

Twitter emerged as the favorite social network for scientists and health professionals. The main reason for its rise in popularity was due to the breadth of the audience it could reach; these ranged from specialists to students, patients and the general public (Pershad *et al.,* 2018). Also virtual conferences were organized to promote digital communication strategies, with Twitter being the most widely used application. The almost immediate dissemination of new knowledge and online interactions greatly amplified the reach of medical conferences, enabling enhanced possibilities for professional connections (Banerjee *et al.,* 2021).

### 2.5. Disinformation, production, and retraction of false studies

During the COVID-19 pandemic, much false information was generated and spread rapidly among individuals and organizations (WHO, 2020). It is estimated that the infodemic hindered the implementation of virus control measures. This promoted the spread of fear, unnecessary confusion, and division at times when collaboration was required to save lives and end the health emergency (Adhanom & Ng, 2020). Certainly, during the health crisis, false information also triumphed. This is revealed by the report developed by the Health Without Hoaxes Institute, a proposal of the media agency Com Salud in conjunction with the Association of eHealth Researchers (AIES). The report described the different conspiracies about the origin of the pandemic and false remedies to treat the disease (Salud sin Bulos, 2020).

For Kouzy *et al.,* (2020), the evaluation of messages posted on Twitter marked with 14 *hashtags* indicates that health misinformation and unsubstantiated content on this topic spread at a worrying rate on social networks. Moreover, the generation of this false information was generally done by non-health expert users. Similarly, Quian (2023) points out that, although many studies were disseminated by Twitter, the downside of misinformation about health spreads rapidly through all social platforms. Most prominent were helpful videos with false content.

Consequently, we sought to address and counter Covid-19 virus-related infodemics (Mheidly & Fares, 2020). In the view of

non-experts, the handling of scientific information is hardly an inconvenience for those who doubt taxing claims, personal perceptions, or the dissemination of information under the *prime time* approach (as a reaction of a mercantile objective) or fake news (Muselli *et al.,* 2021). Within this framework, pressure from manipulated groups of society generated uncertainty in the population and chaos in the veracity of information. This disturbed the construction of consensus, fostering the ideological rupture that leads to distrust and finally to society being violated by a center of power with economic, political, or cultural intentions (Montoya, 2021).

### 2.6. Changing research priorities and exponential growth of the literature

As mentioned above, the number of articles on Covid-19 increased dramatically (Rousseau *et al.,* 2023). However, science faces different risks, considering that the urgency to publish caused many journals to delay other relevant research. Likewise, there has been a large dissemination of information without scientific verification, with methodological deficiencies and inadequate recommendations. This is something that can violate the safety and health of people (Sequera, 2020). More than 125,000 scientific studies associated with the disease were published during the ten months following the confirmation of the first case. Of these studies, more than 30,000 were stored on preprint servers (Fraser *et al.,* 2021).

The response to the COVID-19 pandemic crisis corroborates the historical perception that any profound crisis represents an opportunity for radical transformation. The scientific community has demonstrated its ability to react almost immediately to this challenge, forming interdisciplinary working communities, mobilizing resources in record time, establishing various innovative ways, and creating new scientific opportunities in the face of this crisis (Corbera *et al.,* 2020).

## 3. METHODOLOGICAL ASPECTS

This documentary-type study focuses on the search, analysis, and interpretation of secondary data. Therefore, the information was obtained from studies conducted by other researchers and from documentary sources (Arias, 2012). The design was bibliographic since information contained in bibliographic sources was interpreted (Mejía, 2005). A systematic review methodology was followed to gather information and prepare a summary on a specific topic, the objective of which was to answer the two questions of interest previously presented in the introductory section (Aguilera, 2014).

### 3.1. Search process

The databases used for the study searches were Scopus, Web of Science, ProQuest, and PubMed. The search was carried out from January 1, 2020, to March 31, 2024, considering that the WHO (2020) declared the COVID-19 virus a pandemic in 2020. Descriptors and keywords such as "COVID-19" and "scientific communication" were used to retrieve the documents. These were used in the title, abstract, and keywords through the Boolean operator "AND."

### 3.2. Inclusion and Exclusion Criteria

The inclusion criteria for the selection of publications were as follows:

1) original articles;
2) articles published between January 01, 2020 and March 31, 2024;
3) articles prepared in any language; and
4) open access articles.

With respect to the exclusion criteria, the following were established:

1) articles that do not address the subject,
2) repeated items,
3) systematic review articles,
4) bibliometric review articles, and
5) letters to the editor and expert opinions.

### 3.3. Conformation of the sample

Based on the above procedures, 64 publications were identified. After applying the inclusion criteria, the number of publications was reduced to 41. After applying the exclusion criteria, 16

papers remained. As the presence of the terms "Covid-19" and "Scientific communication" was an established criterion, four papers were discarded, leaving a final sample of 12. Figure 1 shows the PRISMA diagram, which illustrates the final sample's search process, identification, and selection for the present systematic review study.

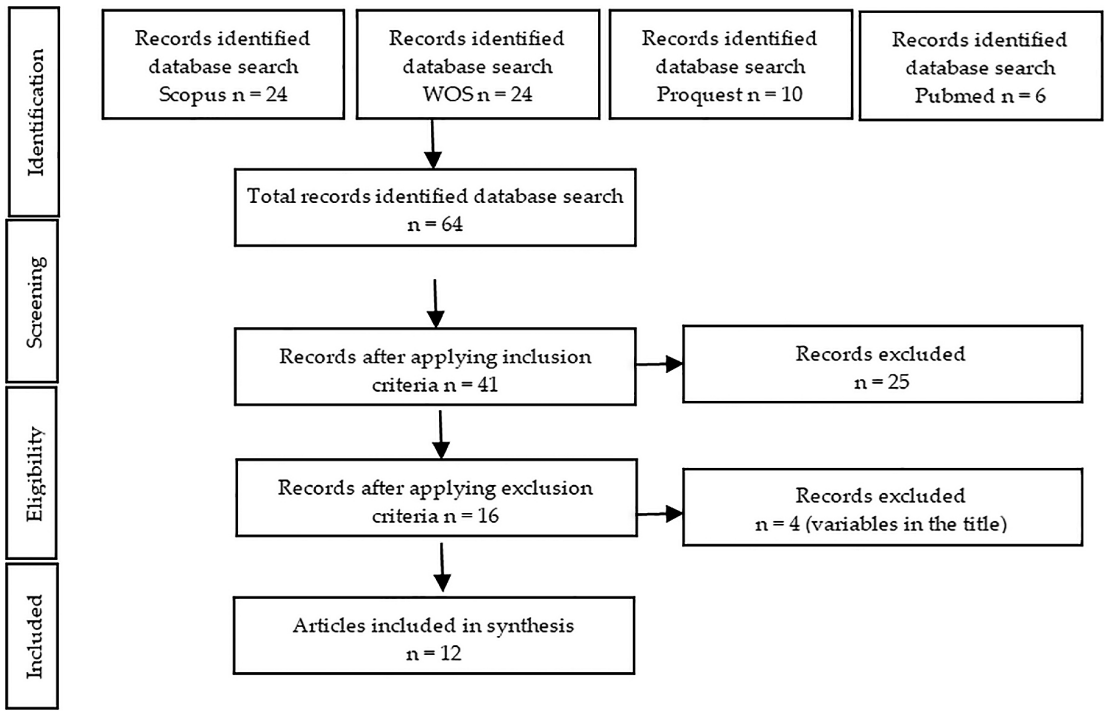


**Figure 1.** PRISMA diagram.

### 3.4. Quality of the selected studies

The articles selected met various scientific criteria that facilitated the extraction of relevant information based on their findings. This process made it possible to draw conclusions focused on these findings and determine the limitations observed, aiming to perform a reproducible and bias-free analysis. Although there are tools for assessing the quality of systematic reviews, the verification scheme presented in Table 1 was used in this study.

| Criteria | Description |
|---|---|
| Validity | All the articles included in the sample are recent studies related to the impact of scientific communication during the Covid-19 pandemic. |
| Strictness | The selected studies are the most relevant in the area and also used valid and reliable instruments. |
| Amplitude | Of 64 studies found in the databases, the number selected for the review is considered sufficient. |
| Risk of bias | The findings of each study were reviewed and analyzed in general and, according to the evidence, it can be inferred that they do not present biases that question the credibility of the review. |
| Organization | The review was carried out in an orderly and systematic manner, following the established methodology. |
| Relevance | The approaches of the selected studies are appropriate for further study of the subject. |
| Clarity | The narrative of the review is adequate from a grammatical and syntactical point of view, as well as being fluent and understandable. |
| Accuracy | The concepts used are in accordance with the lexicon of the area of study and the aspects described. |

**Table 1.** Quality criteria for the studies' selection.

## 4. RESULTS

The results reflect that two articles were published in 2024, one in 2023, two in 2022, two in 2021, and five in 2020 (See Table 2). They were also published in twelve different journals. Three of the articles were developed using a mixed methodology, six qualitatively, and three using a quantitative methodology.

| Author (Year) | Title | Journal | Methodology |
|---|---|---|---|
| Rediger & Beer, (2024) | Booster for partizipative scientific communication? Effects of the Corona-Pandemie on the communication of scientific knowledge in the Informationsdienst Wissenschaft and in Regionalzeitungen. | Media & Communication Science | Mixed |
| Martin *et al.* (2022) | Scientific communication after the COVID-19 crisis: TikTok publishing strategies on the transmedia board. | Revista Latina de Social Communication | Qualitative |
| Kalabamu (2020) | Promotion of unproved and potential dangerous measures in fighting COVID-19 pandemic: urgent need for vigilant appropriate public communication and generation of scientific evidence | Pan African Medical Journal | Qualitative |
| Sakai (2024) | Advice as a Form of Structural Coupling: Intersystem Organizations and Scientific Communication in the Japanese Response to COVID-19 | Systemic Practice and Action Research | Qualitative |
| Wu & Mackenzie (2021) | Dual-Gendered Leadership: Gender-Inclusive Scientific-Political Public Health Communication Supporting Government COVID-19 Responses in Atlantic Canada. | Healthcare | Quantitative |
| Antunez *et al.* (2022) | Scientific dissemination and teacher training: Extension possibilities in the covid-19 pandemic. | PROMETEICA - Philosophy and Science Magazine | Qualitative |
| Xie *et al.* (2022) | Understanding the Scientific Topics in the Chinese Government's Communication about COVID-19: An LDA Approach | Sustainability | Quantitative |
| Campos *et al.* (2022) | Trends in scientific communication and continuing education in Forensic Sciences during the pandemic of COVID-19: The role of virtual conferences and experiences of the 2020 Online Congress of the Brazilian Society of Forensic Sciences | Brazilian Journal of Analytical Chemistry | Qualitative |
| Pollett & Rivers (2020) | Social Media and the New World of Scientific Communication During the COVID-19 Pandemic | Clinical Infectious Diseases | Qualitative |
| Santos *et al.* (2020) | Public communication and scientific dissemination in times of COVID-19: actions developed at the Federal University of Uberlândia - Brazil. | Spanish Journal of Health Communication | Mixed |
| Elias (2020) | Scientific experts and governmental communication in the era of fake news. Analysis of the Covid-19 information strategy in Spain. | Prisma Social Magazine | Mixed |
| Wegwarth *et al.* (2020). | Assessment of German Public Attitudes Toward Health Communications With Varying Degrees of Scientific Uncertainty Regarding COVID-19 | JAMA Network Open | Quantitative |

**Table 2.** Selected research.

### 4.1. Aspects impacting scientific communication during the COVID-19 pandemic

Table 3 presents the aspects that had a profound and multifaceted impact on scientific communication during the COVID-19 pandemic. It was found that most of the studies in the sample focused on the dissemination of scientific communication and misinformation, considering the different variants of adaptation to improve the transmission of scientific information related to the virus, its spread, prevention measures, and possible forms of cure. The Covid-19 crisis exposed the vulnerability of the scientific system to the production and retraction of false studies, exacerbating disinformation and undermining public confidence. The proliferation of fake news and conspiracy theories complicated the task of scientists and authorities to inform the public effectively.

Scientific advice became fundamental, although its integration into policy varied significantly between countries, affecting the effectiveness of public health measures. Science communication outreach gained relevance, with academic institutions and the media striving to translate complex findings into understandable messages. Science communication trends shifted towards using digital platforms and social networks for faster and wider dissemination. Finally, the role of the public became more critical, with a greater demand for transparency and accuracy in scientific information, reflecting an increased awareness of the importance of science in everyday life.

| Appearance | Development | Author (Year) |
|---|---|---|
| **Cooperation and gender inclusion in scientific communication**<br>Female leadership in improving science-policy communication during the pandemic. | We quantitatively examined how gender-inclusive science-policy cooperation supported effective responses at the provincial level in Canada during the first two waves of Covid-19. This case study reveals that: at the provincial government level, female leadership in mitigation, advocacy and coordination incentivized authorities to adapt science-based interventions and provide consistent and supportive public health information to the general public; and at the community level, this inclusive leadership promoted community cohesion in managing the spread of Covid-19. | Wu & Mackenzie (2021) |
| **Production and retraction of false studies**<br>Correction of misinformation and development of clinical trials to generate scientifically sound evidence on Covid-19. | The desperate situation caused by the pandemic that led to the adoption of extreme preventive measures, many of which are purely rhetorical, have not been scientifically proven, and some of which may be more dangerous than the virus, was discussed. Unfortunately, some of these measures are promoted by respected members of the scientific community. Despite this crisis, it is critical to advocate for treatments and interventions that are scientifically sound and evidence-based. | Kalabamu *et al.* (2020). |
| **Disinformation**<br>Study of the scientific communication patterns of Chinese governmental sources on Covid-19. Analysis of the information and communication strategy on Covid-19 in Spain, with the advice of experts and scientists in the era of fake news. | Data from 1521 press reports issued by the Chinese government, related to scientific issues, were collected and analyzed. An LDA (Latent Dirichlet Assignment) topic model, correlation analysis and ANOVA were applied to examine the framing of scientific topics and their socio-environmental characteristics. The findings indicate that the frames used in Chinese government communication on scientific topics related to Covid-19 had three main objectives: to disseminate knowledge on disease prevention and control, epidemiological research, and promotion of the public's personal health; to inform the public about scientific research and development in Chinese medicine, enterprises, vaccines, treatment options, and medical resources; and to involve citizens, communities, and enterprises in scientific decision-making. | Xie *et al.* (2022) |
| | It examines how the Spanish government used scientific experts in its institutional communication during the Covid-19 pandemic. The European Council for Foreign Relations (ECFR) survey indicates that Spain is one of the countries that least trusts its experts during the coronavirus crisis. A case study of the "State of Alarm" period is carried out to delve into the historical and media causes that may explain why public opinion in Spain distrusts experts linked to the government. In addition, failures in the institutional communication strategy that negatively affect the image of scientists and science are identified. | Elias (2020) |
| **Scientific advice**<br>Counseling as a form of structural coupling in intersystemic organizations and scientific communication, in Japan's response to Covid-19. | It is empirically illustrated how the structural coupling between the policy system and the science system through advice manifests itself in the analysis of the roles played by various organizations in Japan's response to Covid-19. A theoretical perspective on these organizations and a detailed analysis of the transformation of certain entities are provided to reinterpret the theoretical ideas of the advisory system in scientific communication between politics and science. | Sakai (2024) |

| Appearance | Development | Author (Year) |
|---|---|---|
| **Dissemination of scientific communication**<br>Participation of undergraduate students in science outreach, and their contributions to their teacher training in the context of the Covid-19 pandemic. Impact of the Covid-19 pandemic on the dissemination of scientific knowledge. Adaptation of science journalism to the digital environment and the potential of TikTok as a platform for scientific dissemination after the health crisis. Role of social networks in scientific communication during the Covid-19 pandemic. Actions developed at the Federal University of Uberlândia, Brazil, on public communication and scientific dissemination in times of Covid-19. | It is characterized by developing synchronous meetings with students, which address current scientific topics. The findings reveal that, although the remote environment hinders interactions among the participating students, they were able to express their doubts and opinions throughout the meetings. The activity constitutes an important formative component for future teachers, allowing them to learn about the reality of distance teaching in basic education and the difficulties faced by teachers during the pandemic. | Antunez *et al.* (2022) |
| | Based on three case studies influencing multidirectional pandemic spread and participatory science communication, an initial categorization of 127 existing science communication formats was made, based on their objectives and their approach to participation and/or multidirectionality. | Rediger & Beer (2024) |
| | The opportunity that science journalism has in the transmedia environment is highlighted, as a resource to reach new audiences. It highlights the advantages of graphics, accessibility and immediacy, as well as recommendations on the content, style and interaction with users of the messages disseminated in TikTok. It underlines the critical importance of professionals and media adapting to these new environments as a key factor for their sustainability. It recognizes that this is not simply about fads, but about the challenge of regaining the trust of audiences and ensuring long-term viability. | Martin *et al.* (2023) |
| | It is suggested that Twitter has played an essential, albeit limited role in real-time global communication between scientists during the Covid-19 epidemic. Three key aspects of Twitter-facilitated scientific exchange during public health emergencies are examined, along with some significant drawbacks. This serves as an introduction to some of the essential epidemiological analyses during the initial stages of the Covid-19 outbreak, observed through the prism of a Twitter account. | Pollett1 & Rivers (2020) |
| | Actions are proposed for the development of scientific communication on Covid-19, by the Division of Scientific Dissemination of the Federal University of Uberlândia (Minas Gerais, Brazil). A documentary, descriptive and field research was developed, where productions about the coronavirus were collected and presented, from February 6, 2020 to May 8, 2020. It revealed significant efforts to create dissemination content about Covid-19 through scientific journalism, with the intention of promoting public communication of science. | Santos *et al.* (2020) |
| **Trends in science communication**<br>Role of virtual conferences and experiences of the Brazilian Society of Forensic Sciences Online Congress 2020 in scientific communication during the pandemic. | The benefits and possibilities of virtual congresses in Forensic Sciences, Chemistry and Forensic Toxicology are discussed in terms of promoting scientific communication, accessibility, diversity and continuing education. The experiences of the Brazilian Society of Forensic Sciences with the SBCF 2020 online congress are analyzed. The experiences gathered from the 2020 virtual scientific meetings showed that these formats are promising and relevant, and should be increasingly integrated in future scientific events as an alternative strategy to foster scientific communication. | Campos *et al.* (2021) |
| The role of the public in science communication<br>German public attitudes toward health communications with varying degrees of scientific uncertainty related to Covid-19. | We assess people's preferences for health communications with varying degrees of scientific uncertainty in the context of the Covid-19 pandemic and explore factors associated with the preferred form of communication. It is considered that presenting uncertain aspects of the pandemic as if they were certain may undermine public confidence and affect compliance with containment measures if such reports subsequently turn out to be incorrect. | Wegwarth *et al.* (2020). |

**Table 3.** Summary of the aspects that impacted scientific communication during the pandemic.

### 4.2. Conclusions on the impact of the COVID-19 pandemic on scientific communication

Table 4 describes the findings of the studies that made up the sample of this systematic review. For example, in Canada, women played a fundamental role in the communication and formulation of public health policies, standing out for prioritizing citizen welfare over economic interests and promoting interdepartmental inclusion and cooperation. At the global level, there is a clear need for controlled studies on traditional supplements to combat misinformation and promote evidence-based interventions. In China, science communication was oriented towards public education and community participation. Meanwhile, in Japan, bureaucracy influenced the selection of experts and policy recommendations. The pandemic also revealed the importance of scientific dissemination in dialogue between universities and schools, overcoming hegemonic approaches and promoting interdisciplinarity.

Science communication also adapted to unidirectional formats during the crisis, highlighting the importance of reporting with rigor and creating attractive content for the general public. Social networks, especially Twitter, became a valuable but ambivalent resource for science communication. Finally, the pandemic underlined the relevance of public communication of science, highlighting the crucial role of journalists and communicators in maintaining effective contact with the public.

| Appearance | Conclusion | Author (Year) |
|---|---|---|
| Cooperation and gender inclusion in scientific communication | In the Atlantic Bubble, women influenced scientific-political communication and the implementation of better policies during the first and second waves of the pandemic in Canada, establishing close collaboration with their male colleagues and effective communication with the public. Particularly in the realm of public health policymaking, women prioritized the health and well-being of citizens over economic interests through a more balanced approach to reopening once public health risks were deemed mitigated. Their leadership roles promoted the inclusion of messages serving vulnerable populations and facilitated interdepartmental cooperation at the provincial government level. | Wu & Mackenzie (2021) |
| Production and retraction of false studies | There is a need to develop randomized controlled studies to evaluate the safety and efficacy of traditional and nutritional supplements promoted as safe in order to gather sufficient scientific evidence in the fight against Covid-19. Scientists must take the lead in actively debunking misinformation and advocating for evidence-based public health interventions. | Kalabamu *et al.* (2020. |
| Disinformation | The main findings reveal that the Chinese government's science communication approaches on Covid-19 have three objectives, to disseminate knowledge on prevention and control; to facilitate public understanding of scientific R&D in Chinese medicine; and to involve citizens, communities, and enterprises in scientific decision-making. The approaches are correlated with public and media concerns. Approaches vary according to different levels of officials, types of government agencies, regional government revenues, and levels of epidemic severity. Issues related to sustainability science are correlated with public and media concerns. | Xie *et al.* (2022) |
| | The strategy of both the government and the opposition, regardless of their political affiliation, when faced with information that, although true, is unfavorable to them, has been to label it as fake news, which, in fact, gives legitimacy to the rumors, since it compares them to critical information, which is not the same thing. All this undermines confidence in the government, even when it makes sound decisions, which there have been. And, above all, it undermines the credibility of something more transcendental than any government: the credibility of science and scientists. Governments, political parties, and even countries and empires, may disappear, but scientific principles endure forever. | Elias (2020) |
| Scientific advice | In the Japanese case, the bureaucracy plays a central role in the selection of expert advisory board members. In addition, a very detailed empirical investigation is required, and how the recommendations of the advisory organizations are coordinated with policy makers. Therefore, it is relevant to establish whether the functioning of the scientific system can be considered as a stimulus for the understanding of specific problems of the political system (e.g. interest groups, associations, etc.) and as a resource for their solution. | Sakai (2024) |

| Appearance | Conclusion | Author (Year) |
|---|---|---|
| Dissemination of scientific communication | It can be considered that scientific dissemination, as an extensionist practice, facilitates a dialogic interaction between the university and the school, overcoming the hegemonic discourse of the university system and promoting an environment conducive to the exchange of knowledge. This practice allows teachers and students to understand dynamics different from those traditionally addressed in their formative trajectories. Regarding interdisciplinarity and interprofessionalism, it was found that it is possible to incorporate theoretical and practical coherence in teaching actions through alliances between the university and basic education schools, considering the plurality of areas of knowledge, teaching models, experiential knowledge and visions of science. | Antunez *et al.* (2022) |
| | The categorization of 127 science communication formats served as a basis for analyzing the formats used in the science industry information service, the science service (idw) and in the local section of regional newspapers, before and during the pandemic. The results suggest that participatory or multidirectional science communication received no impetus during the pandemic. In the acute crisis period of 2020, science communication focused on meeting the demand for established, one-way science information, creating formats at both regional and national levels. | Rediger & Beer (2024) |
| | It is also essential to create communities around science and generate attractive content for audiences unaccustomed to this type of information. A repetitive use of social networks should be avoided, taking advantage of all their narrative possibilities and, ultimately, contributing to reinforce the value of professional practice in a context of media discredit. | Martin *et al.* (2023) |
| | Twitter is a valuable resource for discussing warnings and future directions in the application of infectious disease models, as well as in decision making related to Covid-19. However, this social network became a double-edged sword in scientific communication during the current Covid-19 pandemic. Scientists should exercise caution when communicating their research using these social networking platforms as this outbreak evolves during 2020. | Pollett & Rivers (2020) |
| | The importance of public communication of science is highlighted, especially during times such as the coronavirus pandemic, when public interest should be based on scientific criteria. The results suggest that efforts dedicated to public communication can and should be considered as one of the most relevant aspects of the process of broadening communication practices in science communication. In addition, the role of the actors responsible for science communication, whether journalists or communicators, as well as scientific sources, who maintain direct or indirect contact with the public, is recognized. | Santos *et al.* (2020) |
| Trends in science communication | It is important to consider the benefits of virtual conferences for future Forensic Science congresses as an additional alternative for scientific communication and networking, with the potential to improve accessibility and diversity. This format can be effective in fostering and supporting partnerships and collaborations both nationally and internationally, as well as providing scientific content. In addition, these virtual models can complement face-to-face events, leveraging the advantages of both types of scientific conferences and maximizing the impact of the event. | Campos *et al.* (2021) |
| The role of the public in science communication | For those who show skepticism toward governmental containment measures, it appears that communication expressing uncertainty was particularly effective in motivating them to comply with such measures. However, the general applicability of these findings may be limited by the fact that the sample consisted of German residents. These results are surprising, suggesting that the communication of uncertainty tends to generate avoidance and higher levels of discomfort. Speculating that respondents, and possibly people worldwide, may be more receptive to the communication of uncertainty in the context of Covid-19, because both the individual and collective experience of the pandemic involves rapidly evolving knowledge and a lack of certainty. | Wegwarth *et al.* (2020) |

**Table 4.** Summary of the main conclusions of the selected studies.

## 5. DISCUSSION AND FINAL CONSIDERATIONS

The COVID-19 crisis revealed the vulnerability of the scientific system, especially the development of preprints, false studies, and retractions. All this exacerbated misinformation and undermined public confidence. The proliferation of fake news and conspiracy theories complicated the task of scientists and policymakers to report effectively. Despite these challenges, science communication gained relevance with the increased use of digital platforms and social networks for faster and wider dissemination, reflecting a growing public demand for transparency and accuracy in the information disseminated.

Lobera & Torres (2021) express that disinformation is limited to the dissemination of incorrect content and the intention to misinform through the use of biased and misleading information. In this context, science communication was undermined by the malicious incentives present in news companies, from digital newspapers to social media platforms. Therefore, it was imperative that authors, researchers, journal editors, and websites specialized in the subject assumed ethical responsibility at all stages of the process, from the conception of the research to the communication of results. All this even when faced with time constraints (Beldarrain, 2020).

Mheidly & Fares (2020) point out that the COVID-19 outbreak made dealing with emerging infectious diseases difficult. Although the rapidity of spread may have been adverse to rigorous science, the ideal scenario for combating an infodemic required the rapid and wide dissemination of reliable, evidence-based information. The media plays an essential role in raising social awareness, exposing truthful information, promoting healthy habits, and improving psychological well-being. Fraser *et al.'s* (2021) study states that the COVID-19 pandemic generated greater scientific and public engagement with preprints. These preprints were more accessible, cited, and shared on various online platforms compared to preprints that were not related to COVID-19. In addition, changes in their use by journalists and policymakers were observed.

Regarding open access, Robinson and Jimenez (2023) emphasize that this movement in scholarly communication questions many fundamentals of the traditional model and the evaluation system that supports it. However, the study by Nane *et al.,* (2023) reveals a remarkable increase and growth rate in open-access publications during the pandemic, although this growth is comparable to that of non-open-access publications.

Finally, regarding female leadership, the study by Kwon *et al.,* (2023) stated that several factors widened the gender gap, considering the authors' backgrounds in terms of individual, organizational, and national characteristics. Female researchers were more vulnerable if they were mid-career, affiliated with less influential organizations, or came from countries with lower gender equality, higher mortality, and mobility restrictions due to the pandemic.

### Conflict of interest

The authors declare that there is no conflict of interest.

### Statement of data consent

The data generated during the development of this study has been included in the manuscript.

### Contribution statement

Conceptualization: Juan Manuel Sánchez Soto, Henri Emmanuel López Gómez, Uldarico Inocencio Aguado Riveros, Manuel Silva Infantes.

Data curation: Uldarico Inocencio Aguado Riveros, Manuel Silva Infantes, Juan Manuel Sánchez Soto.

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