



Communicating the “Race” for the COVID-19 Vaccine: An Exploratory Study in Newspapers in the United States, the United Kingdom, and Brazil

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The search for an effective solution to control the COVID-19 pandemic has mobilized an unprecedented effort by science to develop a vaccine against the disease, in which pharmaceutical companies and scientific institutions from several countries participate. The world closely monitors research in this area, especially through media coverage, which plays a key role in the dissemination of trustful information and in the public’s understanding of science and health. On the other hand, anti-vaccine movements dispute space in this communication environment, which raises concerns of the authorities regarding the willingness of the population to get vaccinated. In this exploratory study, we used computer-assisted content analysis techniques, with *WordStat* software, to identify the most addressed terms, semantic clusters, actors, institutions, and countries in the texts and titles of 716 articles on the COVID-19 vaccine, published by *The New York Times* (US), *The Guardian* (United Kingdom), and *Folha de São Paulo* (Brazil), from January to October 2020. We sought to analyze similarities and differences of countries that stood out by the science denialism stance of their government leaders, reflecting on the severity of the pandemic in these places. Our results indicate that each newspaper emphasized the potential vaccines developed by laboratories in their countries or that have established partnerships with national institutions, but with a more politicized approach in Brazil and a little more technical-scientific approach in the United States and the United Kingdom. In external issues, the newspapers characterized the search for the discovery of a vaccine as a race in which nations and blocs historically marked by economic, political, and ideological disputes are competing, such as the United States, Europe, China, and Russia. The results lead us to reflect on the responsibility of the media to not only inform correctly but also not to create stigmas related to the origin of the vaccine and combat misinformation.

Keywords: vaccine, COVID-19, coronavirus, science communication, media coverage

INTRODUCTION

Vaccines are important achievements for public health not only for controlling or eradicating diseases but also for reducing health care costs and inequalities between countries (Andre et al., 2008). With 73 million cases and more than 1.6 million deaths in several countries by early December 2020 (Worldometer, 2020), the current COVID-19 pandemic required an unprecedented effort by science to develop a vaccine against the new coronavirus SARS-CoV-2. Until that same period, the World Health Organization counted 162 vaccine candidates in the preclinical phase (animal testing) and 52 in the clinical phase (human trials) (WHO, 2020a).

But just developing a vaccine is not enough for fighting a disease. Especially in a global health emergency, the vaccine must be available in all regions and, above all, there must be a willingness of people to get vaccinated (Schoch-Spana et al., 2020). This has been a challenge for authorities around the world, given the growing vaccine hesitancy (WHO, 2019) and the reverberation of anti-vaccine conspiracy groups (Hussain et al., 2018; Johnson et al., 2020).

In this regard, communication is an important tool for community engagement and social mobilization (Goldstein et al., 2015), and the media is one of the actors in this process (Quinn et al., 2020). With the advancement of the COVID-19 pandemic, the world closely monitors research for the development of a vaccine, especially through media coverage, which plays a key role in the dissemination of trustful information and in the public's understanding of science and health. Studies show that the media can have a crucial effect on risk perception and public protection behaviors (Chen and Stoecker, 2020; Vai et al., 2020).

To better understand how the media have treated this issue, we conducted an exploratory study to analyze the coverage of three major newspapers in the United States, the United Kingdom, and Brazil. At different times of the pandemic, these countries recorded the highest rates of infection and death by the new coronavirus (Worldometer, 2020) and stood out negatively for the science denialism stance of their government leaders (Pollock et al., 2020; The Lancet, 2020; Yamey and Gonsalves, 2020), which motivated us to analyze their similarities and differences.

BACKGROUND

A review by Catalan-Matamoros and Peñafiel-Saiz (2019) shows that traditional media coverage of vaccines has been the subject of research in the recent years. The authors identified 24 studies published between 2007 and 2017, mostly focused on the HPV vaccine. They also identified the predominance of articles from North America (United States and Canada) and the preference for analyzing print media (newspapers and magazines). Regarding the content, most found negative messages about vaccines in the media, which suggest that the current situation may reflect the public discourses that have been circulating for several years.

Meyer et al. (2016) noted that the most common risk messages in Canadian newspapers about the seasonal flu vaccine concerned its possible ineffectiveness, poor understanding of science about the vaccine, and the possibility that it could cause harm, including death. Another study of 250 internet articles on the HPV vaccine also concluded that comprehensive information about the immunizer, the viral infection, and its relationship with cervical cancer was limited (Habel et al., 2009). Therefore, such results show that these issues must be properly addressed, not only when there is a major health crisis.

Studies also suggest the correlation between news consumption and the adoption of certain behaviors. Chen and Stoecker (2020) estimated that every 100 additional media reports about influenza published in October in the United States between 2010 and 2017 were associated with an increase in the vaccination uptake rate of 0.3 percentage points among those aged over 65. This is an important point of attention in the COVID-19 pandemic, since the population was encouraged from the beginning to adopt basic hygiene measures to avoid contamination. A survey carried out in the early stages of the new coronavirus pandemic in Italy identified a crucial relationship between news consumption, threat perception, and the use of protective behaviors, such as social distancing (Vai et al., 2020).

The same is valid for the willingness to get vaccinated. In recent years, the decrease in immunization rates and the resurgence of vaccine-preventable diseases, such as measles, have made the WHO to list vaccine hesitancy among the ten threats to global health. According to the WHO, complacency, inconvenience in accessing vaccines, and lack of confidence are the main reasons for this situation (WHO, 2019). For Goldstein et al. (2015, p. 2), "where and who the messages come from is significant when lack of trust is a driver of hesitancy". In this context, the anti-vaccine discourses and movements are gaining strength, with the fertile ground of social media for the dissemination of disinformation (Hussain et al., 2018).

An analysis of the complex network of activities of approximately 100 million individuals in Facebook between February and October 2019 revealed that, although in a smaller number, the anti-vaccination clusters become central in terms of positioning within the network, while pro-vaccination clusters are more peripheral (Johnson et al., 2020). Regarding Twitter, Wilson and Wiysonge (2020) analyzed more than 258,000 vaccination-related posts between 2018 and 2019 and estimated that a one-point shift upwards in the five-point disinformation scale was associated with a nearly two percentage point drop in mean vaccination coverage over the years. Twitter has even greater weight in the US and Brazil, as it is the social media actively used by the then President Donald Trump and President Jair Bolsonaro.

A review study by Puri et al. (2020) found that, in general, research has shown that anti-vaccine content often generates greater user engagement on social media. However, when analyzing the 100 most engaged hyperlinks between 2018 and 2019, Massarani et al. (2020) observed greater interest of Brazilians in favor of the vaccine but with the limited presence of content produced by academic and scientific institutions. In

addition, among the hyperlinks to texts with positions contrary to the vaccine, most contained false information.

Science denialism, which underlies anti-vaccine movements, also has a political element that has been reflected in the coverage of the COVID-19 pandemic. At the beginning of the crisis in the US, researchers noted that right-wing media outlets were more likely to make inaccurate statements about the origins and treatment of the disease, and people who reported consuming more of these news were later more likely to express misinformed opinions, such as a supposed exaggeration of experts regarding the severity of the pandemic (Motta et al., 2020).

Still in the early moments of the new coronavirus outbreak, Hart et al. (2020) verified an expressive presence of political actors in the US newspapers' coverage, in addition to a high degree of polarization in newspapers and television networks content. This last aspect was even more evident in the case of the COVID-19 vaccine, which mobilized the efforts of great world powers, such as the United States, the United Kingdom, Russia, and China, adding to the crisis elements of nationalism and global competition (Sanger et al., 2020).

As will be shown in the discussion of the results, in our view, political aspects are part of science, but the way in which these issues are addressed by the media can contribute to mitigate or strengthen prejudices. In the United States and Brazil, for example, people were less willing to get vaccinated with a vaccine originating in China or Russia (CPS, 2020; Kreps et al., 2020). This is a worrying scenario, since vaccination is considered more than individual protection, but one way to achieve the so-called herd immunity: the immunization of a large part of the population to reduce transmission and guarantee collective protection (Mallory et al., 2018).

MATERIAL AND METHODS

This exploratory study aims to analyze the coverage on the COVID-19 vaccine in newspapers in the United States, the United Kingdom, and Brazil. In addition to being strategic nations in their regions, these countries were chosen because they were marked by controversial government administrations regarding the outbreak (Pollock et al., 2020; *The Lancet*, 2020; Yamey and Gonsalves, 2020), including vaccination. Until the beginning of December 2020, the US, Brazil, and the United Kingdom were, respectively, the first, the second, and the sixth countries with the highest number of deaths from COVID-19 (Worldometer, 2020). Furthermore, we seek to advance in relation to the research on COVID-19 carried out so far by adding new national contexts and extending the period of analysis, contributing to updating the understanding of science communication during a major health emergency.

Although there is a tradition of studies on science communication in traditional media (Nisbet et al., 2003; Roche and Muskavitch, 2003; Dudo et al., 2007; Medeiros and Massarani et al., 2010), our choice for newspapers was also supported by a resumption of public attention in legacy media as reliable sources of information in the COVID-19 pandemic (Casero-Ripollés, 2020; Vai et al., 2020).

We selected elite newspapers in their respective countries, thus characterized by being historically consolidated commercial news organizations of national daily circulation and with a more balanced coverage in general (Lacy et al., 1991). Because they acquired credibility with the public and within the journalistic community itself, elite newspapers can also influence the coverage of other media outlets (Carpenter, 2007). We also looked for newspapers that made the full content available online, since we were interested in analyzing all publications. Thus, *The New York Times* (United States), *The Guardian* (United Kingdom), and *Folha de São Paulo* (Brazil) were selected.

For the composition of the corpus, we searched the three websites¹ for articles published between January 1 and October 31, 2020, with the keywords *vaccine* and *vaccines*, combined with the keywords *coronavirus*, *covid*, or *pandemic* (in English and Portuguese). As our objective was to analyze only articles which focused mainly on the vaccine, from this initial set, we selected those in which the word *vaccine/vaccines* appeared in the title. The final corpus resulted in 716 articles—339 from *Folha de São Paulo*, 199 from *The Guardian*, and 178 from *The New York Times*.

For the collection of texts, we used web scraping modules developed for the *Python* programming language. All content was stored in an *Excel* spreadsheet, from which the quantitative information of the corpus was extracted: number of articles published over the months, length, and distribution in sections. As it is a vast textual data, for an exploratory content analysis, we opted for a computer-assisted statistical processing, using *WordStat 6*, a text mining software from *Provalis Research*.

Big data analytics has been widely used in studies of large amounts of unstructured textual data, expanding the possibilities in social sciences research (Castelfranchi, 2017). One of the advantages is to be able to work with the full data, rather than using sample selections that can inevitably cause limitations and bias. In addition, the increase in data available on the Internet is accompanied by the development of quantitative and qualitative analysis tools (Cogburn, 2019) capable of exploring not only explicit aspects of the text but also its context, latent dimensions, and semantic aspects (Castelfranchi, 2017). This approach has already been used in studies on communication during health emergencies, such as the Spanish flu (Ewing et al., 2013), severe acute respiratory syndrome (Tian and Stewart, 2005), Zika virus (Wirz et al., 2018), and, more recently, COVID-19 (Liu et al., 2020).

In our study, for the set of articles in each newspaper, the following procedures were performed, adapted from Cogburn (2019): calculation of the most frequent words only in titles; calculation of the most frequent words in the body text; hierarchical clustering; and multidimensional scaling from the proximity and co-occurrence between words.

To calculate the frequency, both in body texts and in titles, we opted for the TF-IDF (Term Frequency weighted by Inverse Document Frequency). The technique is based on the

¹<https://www.nytimes.com/>; <https://www.theguardian.com/>; <https://www.folha.uol.com.br/> [Accessed December 18, 2020].

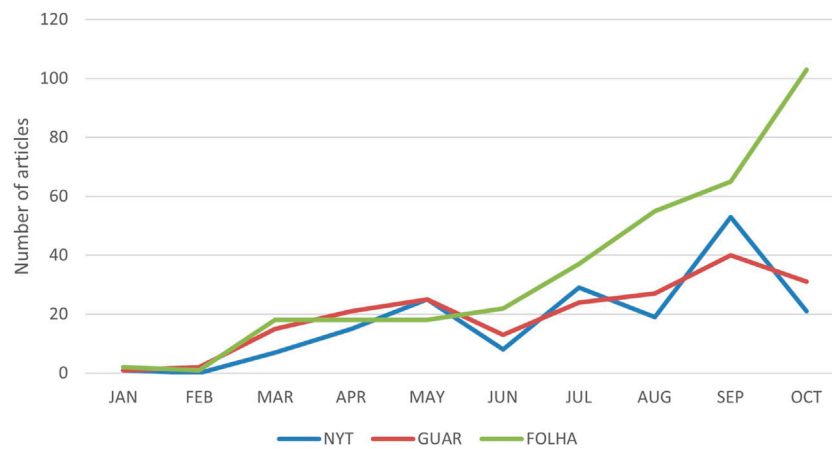


FIGURE 1 | Number of articles on COVID-19 vaccine published from January to October 2020 by *The New York Times*, *The Guardian*, and *Folha de São Paulo*.

assumption that the more often a term occurs in a document, the more it is representative of its content, but this importance needs to be weighed by the number of documents in which it appears (Provalis Research, 2010). According to Cogburn (2019), the calculation allows to identifying words considered more “important” in the corpus. The analysis of the body text corpus was made based on the 100 words with the highest TF-IDF. It was not necessary to define this limit in the title corpus, as the resulting set of words was smaller.

The hierarchical clustering is generated by the software by calculating a similarity matrix, based on the co-occurrence of the words, that is, whenever two words appear in the same paragraph. This option is most appropriate for identifying the co-occurrence of themes in individual subjects (Provalis Research, 2010). Multidimensional scaling is a way of visualizing this proximity on a map, with a graphical representation of the word distribution in the corpus. The map is useful to detect meaningful underlying dimensions that may explain observed similarities between items (Provalis Research, 2010). These tools contribute to detection of patterns in a big textual data.

In an inductive approach, from a first look at the results, we understand that our comparative analysis should focus on the actors, institutions, and countries revealed in these word lists and conceptual maps, since they were representative and revealing of the direction of the coverage of the three newspapers. Finally, to assist in the interpretation of the results, the software tools *keyword-in-context* (which shows all the articles in which a given word appears) and *proximity plot* (which displays a list of the terms that most appear next to a given word) were used. In the next section, we present the main findings, using articles from the corpus to illustrate the results.

RESULTS

General Coverage Characteristics

In the three newspapers, there is a trend for the COVID-19 vaccine articles to increase over time (Figure 1). This growth is

more constant in *Folha de São Paulo*, which reaches its peak in October, with 103 publications. *The New York Times* and *The Guardian* follow a similar pattern of attention to the issue, with a gradual increase until May and falling in June. From then on, the US newspaper mixes periods with more and fewer articles, with September being the month with the highest number (53). The British newspaper, on the other hand, resumes its upward trend until September, which is also the month with the most publications (40), and falls again in October.

Despite having published fewer articles, the texts of *The New York Times* are notably longer than the others, with an average of 1,285 words. *The Guardian* follows with 827 words on average. *Folha de São Paulo*, which produced the largest number of articles in comparison with the other two, is characterized by smaller texts, with an average of 699 words, which represents just over half of that registered in the US newspaper.

We also calculated the distribution of the articles by the sections of each newspaper. Although they adopt different nomenclatures, it is possible to note that, in January and February, the few articles related to a possible vaccine against the new coronavirus were published exclusively in the *Health* or *Science* sections. From March, the subject became much more distributed in other sections, achieving a wide variety of approaches, including *Politics*, *Economics*, *Opinion*, and even *Entertainment* and *Sports* sections. In *The New York Times*, the sections *Health* (65), *Politics* (23), and *Opinion* (16) were the ones that most addressed the topic². In *The Guardian*, the *World* section concentrated most of the articles (107), followed by *Opinion* (21) and *Society* (21). In *Folha de São Paulo*, the distribution was between *Balance & Health* (205), *Columnists* (51), and *Daily* (28).

Coverage Focus

The sets of the 100 words with the highest TF-IDF index in the body texts (Table 1) reveal that *The New York Times* and *The*

²The original names of the sections were kept.

TABLE 1 | Most frequent words in the body texts of *The New York Times*, *The Guardian*, and *Folha de São Paulo*, arranged by the TF-IDF value.

NYT	TF-IDF	GUAR	TF-IDF	FOLHA	TF-IDF
Johnson	141,2	Trial	118,6	Bolsonaro	202,7
Company	122	Trump	105,9	Virus	177
China	120,6	Anti	102,9	Vaccination	168,2
Trial	119,7	Australia	96,2	Millions	166,5
Trump	114,5	Trials	92,7	Production	157,1
Cases	114,2	Virus	88,1	Butantan	152,5
Pfizer	113,8	Fda	87,6	Phase	146,2
Dr	103,5	Countries	86,7	Doses	145,6
Novavax	100,8	Astrazeneca	85,1	Anvisa	145,6
Russia	100,6	Oxford	84,6	Ministry	142,4
Slaoui	100,4	Phase	83,2	President	139,6
Moderna	100,2	Immune	83,1	Volunteers	137
Children	97,3	China	82,6	Vaccines	134,5
Officials	96,9	United Kingdom	82,2	Doria	134,3
Inovio	96,7	Vaccination	81,6	Institute	132,6
Trials	94	Heeney	80,5	Government	128,8
Astrazeneca	92,9	Flu	79,3	Tests	127,8
Russian	92,8	Facebook	77,8	Studies	126,6
Phase	91,5	Doses	77,2	Country	125,9
Immune	89,2	Cases	75,3	Prove	125,9
Chinese	89	Global	74,4	Study	125
Stock	87,1	Public	74,4	Russia	121,9
Researchers	86,5	Research	74,3	People	121,2
Intelligence	85,5	Eu	74,1	Technology	121,2
State	84,9	Challenge	74,1	Adenovirus	120,8
Countries	84,3	Government	73,1	Results	120
Volunteers	81,2	Russian	73	coronavac	119
Percent	81,1	Russia	72,7	Data	116,9
White	80,7	Cells	72,4	Antibodies	116,2
Wednesday	80,3	Home	71,1	Countries	116,1
Government	79,9	Human	70,8	Oxford	115
Students	79,8	Volunteers	69,4	Brazil	114,3
House	78,7	Cell	68	Answer	114,1
Doses	78	Gavi	67,3	Company	113,9
Federal	77,6	Testing	66	Clinical	112,7
Million	77,5	Company	66	Cells	112,6
Flu	76,8	Bn	65,9	Safety	110,6
Antibodies	76,5	Companies	64,7	Minister	109,1
Djokovic	76	Clinical	64,3	Efficacy	108,8
Vaxart	75,8	Sars	64,1	China	108,5
Cells	75,5	Safety	63,6	Actions	107,1
City	75,5	Vaccines	63	Population	106,7
Data	75,1	Scientists	62,7	Paulo	105,9
Country	75	Risk	62,4	Immunization	105,8
Companies	74,4	Development	62,1	Bcg	105,8
Polio	73,3	Team	61,8	Purchase	105,2
Scientists	72,8	Country	61	Research	104,5
Tuesday	72,8	Access	60,7	Health	104,4
Virus	72,6	Drug	60,3	Humans	104,1
Barouch	72,6	Response	60	Disease	103,6
Speed	70,1	Pharmaceutical	59,7	Agency	103,1
Agency	70	Infection	58,7	Sinovac	103,1
Challenge	69,9	Pandemic	58,6	Sputnik	102,4
Participants	69,5	Protein	58,1	astrazeneca	101,7
Department	69,5	Data	58,1	Researchers	101,1
Public	68,6	Study	58,1	State	100,4
Emergency	68,4	Days	58	R	100,1
Care	68	Work	58	Development	98,6
Patients	68	Manufacturing	57,9	Sars	98
Week	67,4	Economic	57,7	Fiocruz	97,8
Institute	66,7	Year	57,5	Chinese	97,1
Billion	65,6	Told	57,4	Immunizing	95,7
Parents	65,5	Covax	57,4	States	95,5
Reported	65,5	Health	57,3	Case	94,8

(Continued on following page)

TABLE 1 | (Continued) Most frequent words in the body texts of *The New York Times*, *The Guardian*, and *Folha de São Paulo*, arranged by the TF-IDF value.

NYT	TF-IDF	GUAR	TF-IDF	FOLHA	TF-IDF
People	65,2	Safe	57,1	Pazuello	94,6
Day	65,2	Disease	57	New	94,3
Study	64,9	Months	56,7	Cov	94,1
Warp	64,8	Morrison	56,5	Federal	93,9
American	64,1	Groups	56,4	Immune	93,3
Information	63,5	Article	56,2	University	92,9
Covid	63,3	Candidates	55,6	Use	92,4
Monkeys	62,7	Fauci	55,5	Obligatory	92,3
Ms	62,6	Effective	55,4	Foundation	92,1
System	61,7	Produce	55,1	Essay	92,1
School	61,4	Process	55	National	91,6
Results	61,3	Cepi	54,9	Governor	91,4
Process	60,8	Minister	54,6	United States of America	91,2
World	60,6	Administration	54,5	Russian	91,1
President	60,2	Group	54,4	Cases	91
Placebo	59,9	Johnson	53,7	Risk	90,9
Guidelines	59,8	State	53,5	Obligatoriness	89,7
Protein	59,7	Ensure	53,4	V	89,3
October	59,3	World	53,3	Partnership	89
Administration	59,2	Social	53,2	Us	88,6
Election	59,1	End	53,2	Rna	88
Americans	59	States	53	Laboratory	87,9
Lockdown	58,7	Candidate	53	World	87,8
Risk	58,5	System	52,9	Organism	87,6
Research	58,2	Nhs	52,6	Coronavirus	87
Studies	58,2	Approved	52,3	Register	86,8
Year	57,4	Symptoms	51,9	Who	86,5
Approval	57,4	Make	51,9	Immunity	86,4
Clinical	57,1	Diseases	51,7	United	85,6
Global	56,9	Election	51,4	Participants	85,4
Tested	56,8	National	51,3	Rio	85
Vaccination	56,8	Long	51,1	Effects	84,7
Operation	56,7	Csl	50,9	Scientists	84,6
Measles	56,4	Participants	50,9	Dose	83,8
Canada	55,6	Day	50,5	Phases	83,7
Tests	55,5	Australian	50,5	Pharmaceutic	83,2

Guardian's coverage focused on the trials conducted by pharmaceutical companies for the development of a COVID-19 vaccine. This approach also appears in *Folha de São Paulo* with reference to the testing phases, although there was an emphasis by the Brazilian newspaper on the prognosis to produce a possible immunizer (*production, doses*). A particularity of the British newspaper was the frequent references to the anti-vaccine movement, generally mentioned as obstacles to disease control (*US anti-vaxxers aim to spread fear over future coronavirus vaccine—The Guardian, 5/29/2020*).

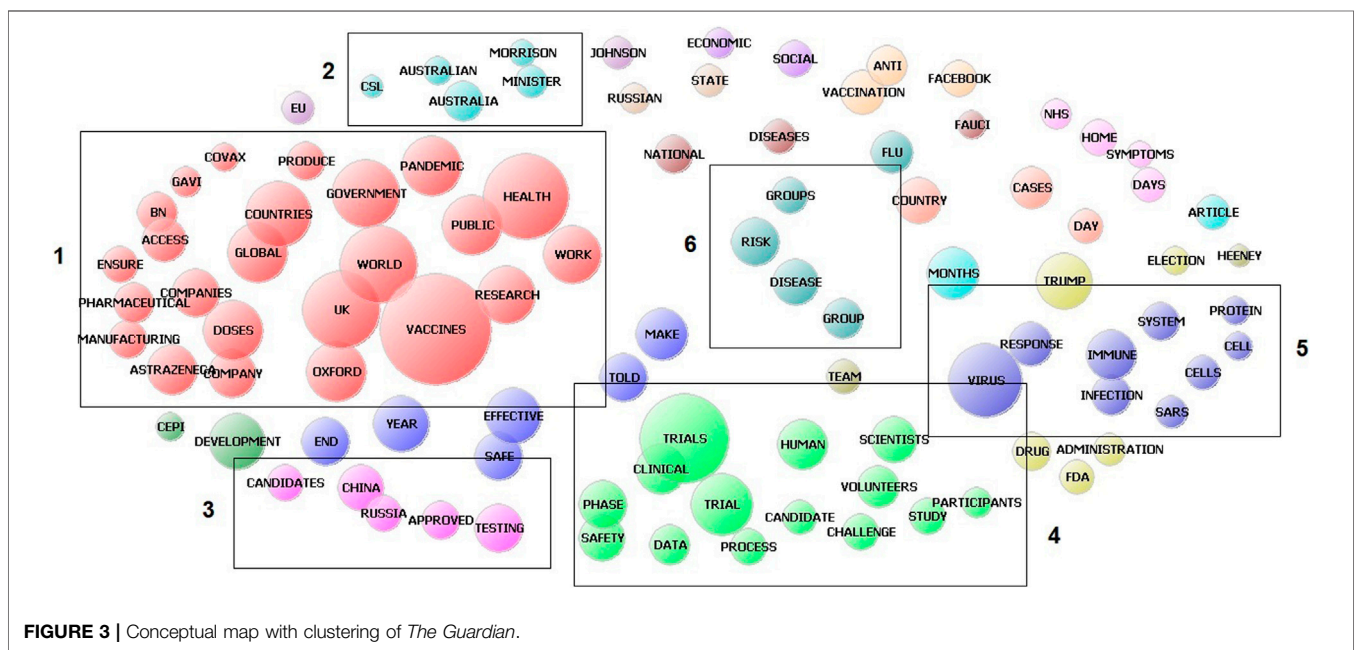
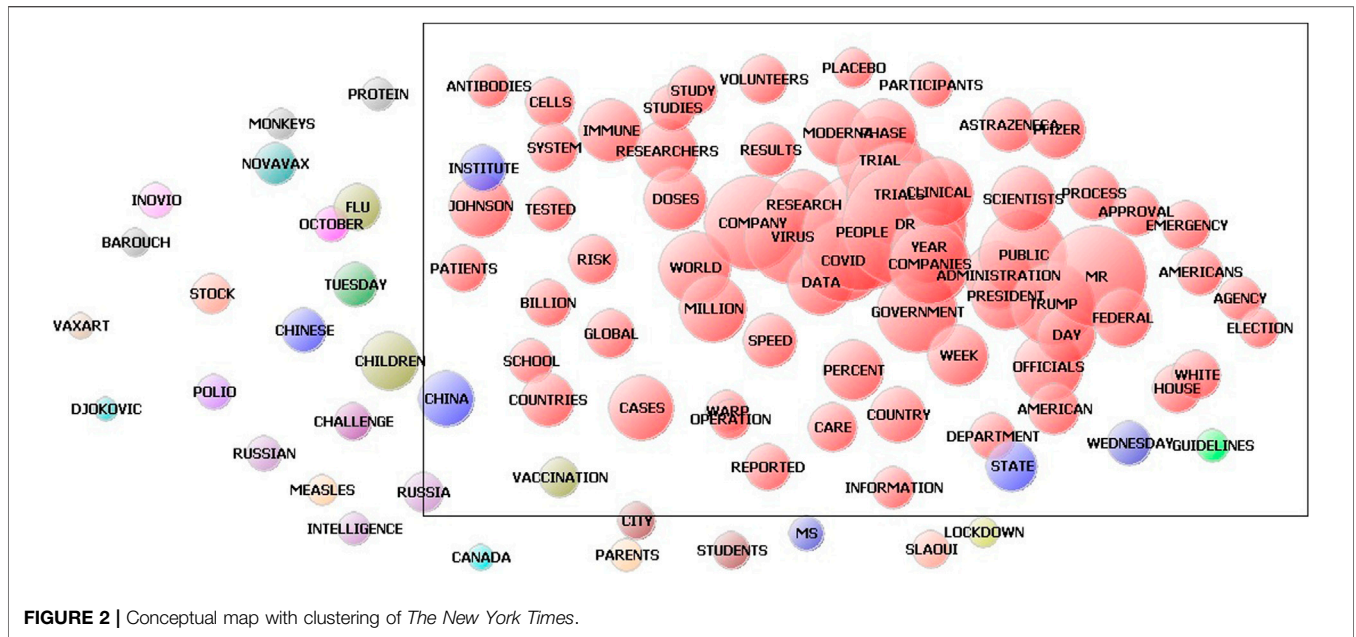
The way this content was distributed can be visualized on the conceptual maps (**Figures 2–4**). The circles represent the most frequent words and are differentiated by the size (the larger the circle, the greater the frequency of the item); by the distance from each other (the closer, the greater the tendency to occurring closer in the texts); and by the color (each color represents a cluster). The images show coverage of several subjects in the same cluster in *The New York Times* and more delimited topics in *The Guardian* and *Folha de São Paulo*.

In the US newspaper, a single cluster dominates the corpus, gathering governmental issues and technical and scientific aspects related to the tests and research conducted by

companies in the country. The other terms are not enough to form well-defined clusters. In the British newspaper, the clusters on the left portion show the division of coverage between the internal context (cluster 1), focusing on the research of the pharmaceutical company AstraZeneca and the University of Oxford, and the external context (2 and 3), which includes China, Russia, and Australia. Technical and scientific issues form well-defined clusters on the lower-right portion (4, 5, and 6).

The same pattern of content distribution can be observed in *Folha de São Paulo*, with the internal references in two clusters on the left (1 and 2), related to political discussions on production, in Brazilian scientific institutions, of vaccines developed by the companies Sinovac (China) and AstraZeneca/University of Oxford (United Kingdom). The cluster on the lower-central part (3) highlights discussions about the obligation to take the vaccine.

The right portion shows two well-defined clusters (4 and 5), which gather technical and scientific terms related to tests, immune response, safety, and efficacy. The external context appears in two clusters: on the upper-central portion (6), bringing together Brazil, the United States, and China and on



the right (7), with references to the immunizer produced by Russia, called SputnikV.

Titles

From the calculation of the TF-IDF frequency of the words only in the titles, we sought to identify the terms that revealed both the subject highlighted in this element of the text and the lexical choices of each newspaper to draw the reader’s attention (Table 2). *Trial/trials* and *test/tests* are terms that suggest news stories focused on updating the vaccine development process, but the particularities of each country’s coverage are evident with the

words *safety* (*Vaccine makers keep safety details quiet, alarming scientists—The New York Times, 9/13/2020*), *potential* (*Coronavirus: the four potential vaccines bought up by United Kingdom—The Guardian, 7/29/2020*), and *obligatory* (*This vaccine will not be obligatory, period—says Bolsonaro about CoronaVac—Folha de São Paulo, 10/19/2020*).

In the three newspapers, the word *race* is also among the most used in the headlines, such as: *Profits and pride at stake, the race for a vaccine intensifies (The New York Times, 2/5/2020)*; *Five organisations in the race to develop a coronavirus vaccine (The Guardian, 5/18/2020)*; and *Vaccine race confronts China and USA*

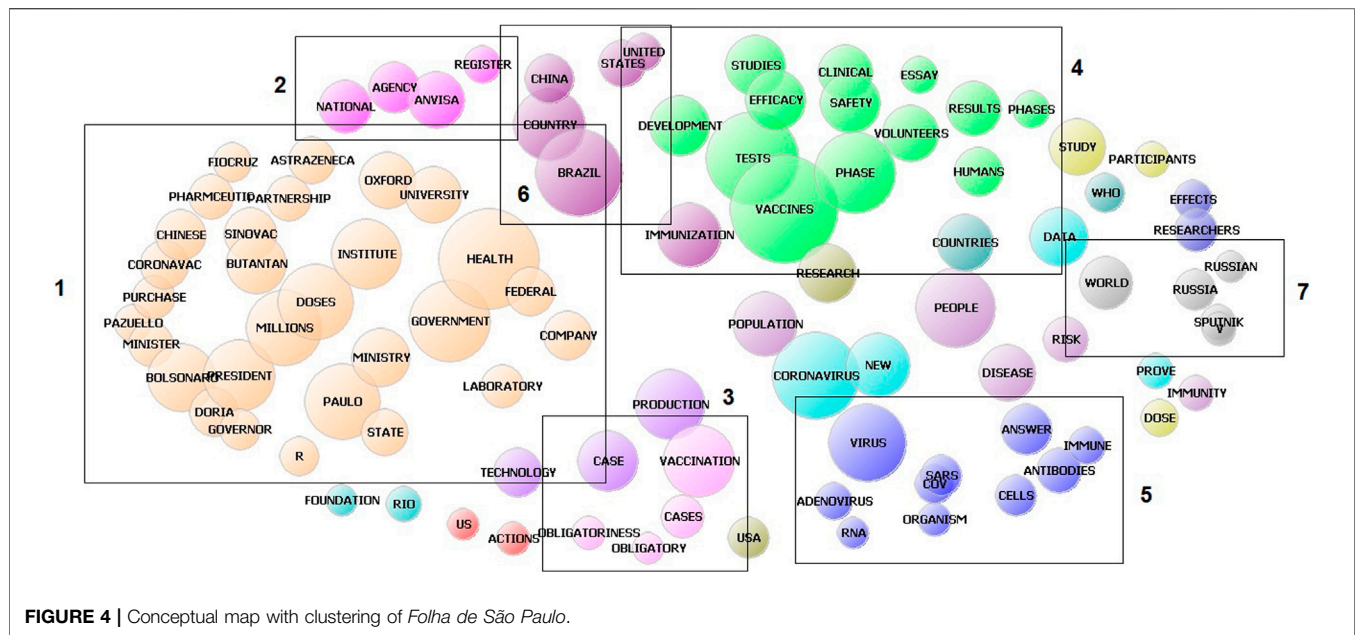


FIGURE 4 | Conceptual map with clustering of Folha de São Paulo.

TABLE 2 | Most frequent words in the titles; and most frequent actors, institutions, and countries in the texts of The New York Times, The Guardian, and Folha de São Paulo.

	The New York Times	The Guardian	Folha de São Paulo
Titles	Coronavirus, vaccines, covid, trump, race, safety, trial, virus vaccine	Coronavirus, covid, UK, oxford, trial, vaccines, trump, race, trials, potential, doses, world, vaccine	Against, covid, coronavirus, vaccines, vaccine, bolsonaro, Brazil, tests, oxford, anvisa, doria, vaccination, Chinese, USA, production, Russia, health, race, test, announce, China, government, obligatory, Russian, sp, study
Actors	Trump, Saloui, Djokovic, Barouch	Trump, Heeney, Morrison, Fauci	Bolsonaro, doria, Pazuello
Institutions	Johnson&Johnson, Pfizer, Moderna, Novavax, Inovio, AstraZeneca, Vaxart	FDA, AstraZeneca, Oxford, Gavi, Covax, CEPI, Johnson&Johnson, NHS, CSL	Butantan, Anvisa, Ministry [of Health], Oxford, sinovac, AstraZeneca, Fiocruz, WHO
Countries	China, Russia, Canada	Australia, United Kingdom, China, European Union, Russia	Russia, Brazil, China, United States of America

again (Folha de São Paulo, 4/17/2020). These examples also illustrate some of the actors that appear in the coverage (world powers and their companies) and the interests mobilized (profits and pride).

There is little emphasis on the name of institutions in the headlines. The University of Oxford is the only institution named in the title corpus, in the headlines of The Guardian and Folha de São Paulo. However, it is necessary to pay close attention to the option of the Brazilian newspaper for the adjectives Chinese and Russian to refer to the vaccines produced in these countries, to the detriment of the name of the respective companies, or research institutes (How is the ‘Chinese vaccine’ going around the world and in Brazil—Folha de São Paulo, 10/17/2020; Russian vaccine research for COVID-19 has been surrounded by secrecy—Folha de São Paulo, 8/11/2020).

International Players

Finally, we identified the countries, actors, and institutions that appear among the 100 words with the highest TF-IDF in the body texts. China and Russia are the countries that emerge frequently in the coverage of the three newspapers (Table 1). The first

country appears with great prominence in The New York Times, being the fourth most important word in the corpus. Russia comes in the 12th. The positions between these two countries are reversed in the Brazilian and British newspapers, where they appear a little less accentuated, but still relevant.

Besides being countries that are undergoing research into the development of vaccines, China and Russia appear in the coverage due to accusations of cybercrime (US to accuse China of trying to hack vaccine data, as virus redirects cyberattacks—The New York Times, 5/10/2020; United Kingdom ‘95% sure’ Russian hackers tried to steal coronavirus vaccine research—The Guardian, 7/17/2020).

Once again, The Guardian pays special attention to Australia and, somewhat less, to the European Union. With a much lower degree of importance, the United States and Canada appear in Folha de São Paulo and The New York Times corpus, respectively.

Actors Involved

Among the actors with the greatest prominence in the coverage, the name of the then president of the United States, Donald

Trump, appears in the first top ten not only in *The New York Times* but also in *The Guardian*, even more prominently than in the US newspaper (Table 1). It is interesting to note that, among the 100 words with the higher TF-IDF in the British newspaper corpus, the name of Prime Minister Boris Johnson does not even appear. *The Guardian's* attention to the American situation is reinforced by reference to Doctor Anthony Fauci, a leading American infection-disease expert. In *Folha de São Paulo*, the name of the president of Brazil, Jair Bolsonaro, presented the highest index of importance among all words.

Still in this aspect, the Brazilian newspaper concentrated its coverage basically on government figures: in addition to the president, the governor of São Paulo, João Doria, and the Minister of Health, Eduardo Pazuello. In the other two newspapers, there is a greater diversity of actors, with representatives of the scientific field, such as Moncef Saloui (scientific adviser of Operation Warp Speed), Dan Barouch (Beth Israel Deaconess Medical Center), and Jonathan Heeney (University of Cambridge).

The coverage of *The New York Times* and *The Guardian* also features characters explored in depth, but in more punctual articles. In the US newspaper, tennis player Novak Djokovic emerges as a denialist voice of the sport, with anti-vaccine discourse and having promoted a match at the height of the pandemic (*Novak Djokovic on coronavirus, vaccines and his ill-fated Adria Tour—The New York Times*, 8/20/2020). *The Guardian's* frequent mention of the name of Australia's Prime Minister Scott Morrison can be explained by the fact that the British newspaper has an edition aimed at that country.

Companies and Institutions

The pharmaceutical companies appear in greater quantity and importance in *The New York Times* (Table 1). In the 100 most frequent terms based on the TF-IDF, there are no mentions of institutions of another nature by the newspaper. Its coverage referred to seven laboratories with vaccines under development, six of them in the US and only one based in the United Kingdom. The other newspapers included public science and technology institutions and universities that work in partnership with pharmaceutical companies, and government agencies linked to public health.

In *The Guardian*, the institution with the most importance in the corpus is from the US—the Food and Drug Administration (FDA). But it is noteworthy that the British newspaper is the only one that devotes some attention to international vaccine development initiatives, such as the Global Vaccine Alliance (Gavi) and the Coalition for Epidemic Preparedness Innovations (CEPI), which participate in Covax, an agreement to guarantee equitable access to vaccines against COVID-19. When referring to these initiatives, some articles from *The Guardian* deal with the problem of equity in the distribution of the vaccine globally (*How will the world's poorest people get a coronavirus vaccine?—The Guardian*, 6/24/2020). The World Health Organization appears only in the *Folha de São Paulo* corpus.

DISCUSSION

Global Media Attention

The COVID-19 pandemic caused an exponential increase in news production and consumption. Liu et al. (2020), in the Chinese context, and Casero-Ripollés (2020), in the United States, verified that this growth occurred as the crisis worsened in the respective local scenarios. In the specific case of the vaccine articles published by *The New York Times*, *The Guardian*, and *Folha de São Paulo*, the coverage intensifies as of March, coinciding with the pandemic declaration by WHO (WHO, 2020c).

There are differences in the number of articles published by each newspaper, but considering the length of the texts, it is possible to state that the three of them provided similar amounts of content. The word distribution in the corpus of each newspaper, revealed in the concept maps (Figures 2–4), is an indication of their editorial choices and the way the news reaches the public in the three countries: topics covered simultaneously in the US newspaper and a more pronounced division of subjects in the British and Brazilian newspapers, but all of them monitoring the issue from the internal and external perspectives.

In any case, the presence of vast online content in these important newspapers is consistent with the pre-pandemic study by Mukerjee et al. (2018). The authors analyzed the US and the British media coverage on the 2016 American presidential election and the 2016 Brexit referendum, respectively. The conclusion was that the two networks exhibited a cohesive core, essentially formed by legacy news outlets, which still stand as the main sources of news online.

The increased interest in the vaccine news can be explained by the fear and anxiety caused by a disease that spreads rapidly, causes deaths, and that, without effective treatment, has in the vaccine the hope of a solution. Another study based on these same newspapers, but focusing on news about preprint scientific articles, sustains this perception by revealing that the research most addressed in these articles had, as the theme, the search for treatment (*drug trials*) and the identification of antibodies in the population (*seroprevalence*) (Massarani and Neves, n.d., in press). The aforementioned study by Liu et al. (2020), which analyzed more than 7,700 articles from Chinese media outlets, also identified the media's predominant focus on *prevention and control procedure and medical treatment and research*.

The Race Metaphor

The results also show how the health crisis gradually stops being a subject restricted to specialized coverage in science and health and starts to cover other sections. In the list of most frequent words (Table 1) and on the maps, there are several scientific terms that go through all the coverage, composing the daily lexicon of the readers. This highlights another characteristic of the COVID-19 pandemic: in the current stage of development of communication technologies, for the first time in history, a pandemic is accompanied by the media uninterruptedly, which includes monitoring research and testing for the development of a vaccine.

The New York Times and *The Guardian*, for example, launched a Coronavirus Vaccine Tracker (Kommenda and Hulley-Jones, 2020; Zimmer et al., 2020). The panels, which indicate the number of immunizers in each phase of testing being researched around the world, are the visual representation of the *race* for the vaccine discovery—a word often used in the articles' titles in the three newspapers (Table 2). Faced with a lucrative and competitive pharmaceutical industry, this is not only a metaphor for speed but also for competition: in a race, whoever gets ahead wins.

The coverage reveals that in the case of the COVID-19 vaccine, the competition is formed by pharmaceutical companies, scientific institutions and, in a more symbolic way, by the countries they represent. Thus, some vaccines are identified not by their laboratory but by their nationality—an aspect that cannot be ignored when the interests of nations and blocs historically marked by economic, political, and ideological disputes are at stake, such as the United States, Europe, China, and Russia. Some articles even position the “competitors” in the dispute: *In race for a vaccine, an Oxford group leads ahead* (*The New York Times*, 4/27/2020); *Russia claims to be ahead of rivals in race to produce COVID vaccine* (*The Guardian*, 8/3/2020); *China “leads race” for vaccine, with two in “final stage”* (*Folha de São Paulo*, 7/7/2020).

The presence of these references in the headlines strengthens the risk of a rapid, incomplete, or biased seizure of the content. This is because the titles are essentially brief elements that need to attract the reader's attention (Condit et al., 2001). In addition, it is worth remembering that newspapers are inserted in social media platforms and the sharing of their news often occurs only from the title (Massarani et al., 2020). Condit et al. (2001) showed that access to the content of a text is essential for the reader to adjust the interpretation of misleading information in the title.

Meaning Construction

We comprehend that all these aspects mentioned so far are inherent to the social dimension of science and, therefore, need to be discussed in the public sphere. But it is necessary to reflect on the meanings that can be constructed from certain media approaches, especially in countries such as Brazil and the United States, where conspiracy theories were driven by their own leaders, whose names appear prominently in the coverage of the respective newspapers. President Donald Trump, for example, was criticized for referring to the new coronavirus as a “Chinese virus”, giving the disease a racist sense (Rogers et al., 2020).

According to Habel et al. (2009), the way the vaccine is labeled in the news can have an impact on the public's perception and, consequently, on the decision to take it. A survey shows that the Brazilian's intention to get vaccinated decreases by 16.4% if the vaccine is associated with China and 14.1% if associated with Russia (CPS, 2020). The number of Brazilians who do not intend to get vaccinated increased from 9 to 22% between August and December 2020 (Datafolha, 2020). In the United States, a study found that a vaccine originating in China was associated with a 10% lower willingness to receive in contrast to one developed in the US (Kreps et al., 2020).

In the United Kingdom, 21% of survey respondents said they were unlikely to get a COVID-19 vaccine and 12% were unsure (YouGov, 2020). McDonnell (2020) states that this percentage does not indicate high levels of anti-vaccine opinions in that country, but the theme has nevertheless received significant attention from *The Guardian*. Movements against vaccination are not recent, but have gained more visibility in the current pandemic (Catalan-Matamoros and Elías, 2020). The anti-vaccine movement is already engaged in the dissemination of misinformation about the COVID-19 vaccine (Quinn et al., 2020) and has its spokespersons sharing inconsistent and contradictory information, as in the case of the sportsman mentioned in *The New York Times* coverage.

Scientific and Political Actors

The major presence of governmental and scientific actors and institutions in our corpus is in line with the result obtained in the review article by Catalan-Matamoros and Peñafiel-Saiz (2019) and by Catalan-Matamoros and Elías (2020) when identifying the sources used by the Spanish press on vaccine stories. However, our study records different incidences according to the newspaper analyzed: more focused on local political and government actors in *Folha de São Paulo*, and on scientific sources and institutions in *The New York Times* and *The Guardian*.

It is verified that the presence of these names in the Brazilian coverage is not simply linked to the choice of sources but to the repercussion of discussions about the origin of the vaccine and the mandatory vaccination in the country, led by political opponents. President Jair Bolsonaro even declared that he would not buy a vaccine from a Chinese company, even though the governor of the state of São Paulo—the most populous in Brazil and one of the most affected by the pandemic—had already signed an agreement with the Sinovac laboratory for the vaccine manufacturing (*Bolsonaro talks about betrayal and says he will not buy Chinese vaccine—Folha de São Paulo*, 10/21/2020). The Chinese company began testing volunteers in Brazil in July 2020, in partnership with the Butantan Institute, an important Brazilian public scientific institution.

It is not by chance that the word *obligatory* appears among the most frequent in the headlines of *Folha de São Paulo*. The results of the other newspapers suggest that the political aspect has been mitigated. In addition to a slight diversity of actors in the US newspaper, the focus is on the word *safety*, while in *The Guardian* the use of the word *potential* to qualify vaccines demonstrates a caution when addressing the subject. The British newspaper covered the international perspective extensively, with great attention to the American and Australian situations, characteristic of the nature of the newspaper itself, which divides its content into four editions: United Kingdom, United States, Australia, and International.

The presence of political actors in the news, especially in Brazil, is indicative of politicization in coverage (Chinn et al., 2020), which is not necessarily negative (Hart et al., 2020). Again, the problem is when the “politicization of science” prevents the adoption of scientific adaptations that would benefit most people (Bolsen et al., 2014) and reaches worrying levels when decisions

imply consequences involving public health and people's lives, such as vaccination. Moreover, the results suggest that the coverage focus of the three newspapers seems to have left other issues in the background, as shown by the little presence of WHO and the limited discussion of social justice in accessing the COVID-19 vaccine by countries.

CONCLUSION

This exploratory study allowed us to identify the general characteristics of the coverage of three important newspapers in the United States, the United Kingdom, and Brazil on the development of a vaccine against COVID-19, contributing to the understanding of the relationship between communication and science in a public health emergency. The use of computer-assisted text analysis techniques made it possible to examine a significant volume of articles published over ten months. We consider that the selection of newspapers from countries characterized by the high incidence of the disease and the controversies involving the management of the crisis was also a differential for allowing a comparative analysis of more varied geographical and economic perspectives, in order to fill a gap identified by Catelan-Matamoros and Peñafiel-Saiz (2019) in relation to the locus of research on this theme.

In general, when focusing on internal issues, each newspaper emphasized the potential vaccines developed by laboratories in their countries or that have entered into partnerships with their national institutions, but with a more politicized character in Brazil and a little more technical-scientific in the United States and the United Kingdom. The external issues brought together the three media outlets, which characterized the search for the discovery of a vaccine as a race in which major world powers participate.

In comparison with previous studies on other vaccines, our analysis suggests that the severity and duration of a health crisis like the COVID-19 pandemic may have contributed to broadening the media's approach to vaccine development,

especially in two aspects—in the technical, with a more detailed coverage of the testing phase and the technologies involved in the research of an immunizer; and in the geopolitical aspect, addressing political, economic, and ideological dimensions that are also part of science.

Such results gain even more relevance since previous research has shown that the media can contribute to the public's perception of health issues, including the decision to get vaccinated. Aware of this, research institutions and scientists have advised on the best communication practices related to vaccines, such as transparency, clarity, dialogue, training, and use of reliable sources (WHO, 2020b; Quinn et al., 2020; Schoch-Spana et al., 2020). Therefore, the media must also be fully conscious of its responsibility not only to inform correctly but also not to create stigmas and combat misinformation.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

Both authors contributed to the study conception and design, data analysis, and article writing.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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