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Miscellaneous

How has COVID-19 impacted the public discourse around vaccines? A comparative analysis of Twitter

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Abstract

This study examines the public discourse about vaccines on Twitter during the COVID-19 pandemic and compares it with the discourses about vaccines before the pandemic. Discourse, users' profile, content, tone, vaccines, and sources of information were manually coded. We have identified a diversity of discourses related to vaccines. The discourse that has stood out the most during the pandemic is related to pandemic management measures. Nevertheless, both denialist and anti-denialist discourses are reduced compared to the previous period. Besides this, less polarization and more neutral discourse were identified during the pandemic. The two periods are expressly marked by tweets with content related to opinions and personal experiences regarding vaccines. Some of them are characterized, in general, by informality in how the users communicate their ideas. Interestingly, users from the medical-scientific sphere did not participate more in Twitter during the pandemic. There were fewer posts including scientific findings and more tweets about patient resources. On the other hand, the media and journalists were very active in this period by disseminating information and issuing vaccine opinions, reflecting their essential role in health crises. However, the presence of television channels, such as Fox News, can be an indication of conservative ideas on vaccines. Thus, the discourses have expressed different meanings in relation to the issue and disputed their legitimacy in this symbolic and virtual market.

Keywords

Discourse, social media, pandemic, Twitter, anti-vaccine, media, disinformation.

1. Introduction

In the 11th century, stories from Chinese literature already gave an account of humanity's tireless search to protect itself against diseases (Quezada, 2020). However, the discovery of the smallpox vaccine in 1796 marked a turning point in the history of prevention. Although the long road traveled has allowed vaccines to prevent around 2 to 3 million deaths per year (World Health Organization, 2019), the health crisis caused by the SARS-CoV-2 coronavirus

has highlighted the important role of immunization to allow returning to normality (Wiysonge *et al.,* 2021).

However, despite the scientific evidence of these benefits, some people hesitate or oppose to be vaccinated, focusing on the possible risks to the detriment of its advantages, a behavior reflected in several European countries and the United States, among others (Sajjadi *et al.*, 2021). This universe consists of people who refuse to be vaccinated and speak loud against vaccination, the so-called anti-vaccine activists, and those who have some level of reluctance to be vaccinated; that is, even if they have access to vaccines, they are slow to accept them or challenge them (European Centre for Disease Prevention and Control, 2023). This behavior is not limited to the coronavirus pandemic as it was growing parallel to vaccine development before the COVID-19 outbreak. For example, many of the conspiracy theories used during the coronavirus pandemic were re-used from previous periods (Catalan-Matamoros, 2020).

Nevertheless, the anti-vaccine movement has escalated during the pandemic, and its consequences may have a long-term impact on global public health. Johnson *et al.* (2020) mapped the content related to vaccines from three billion Facebook users. The authors found that anti-vaccination groups managed to intertwine with undecided groups in the main online network, while pro-vaccination groups were more peripheral. Some mathematical projections on the anti-vaccine movement developed by the authors found that there will be an exponential growth of this type of public perception and understanding, which will be dominant in a decade. Their findings question the widely known understanding we have regarding people's doubts on health issues.

Precisely, social networks have been used by people opposed to vaccines to spread controversial ideas about the side effects of vaccines, resorting to dubious information without a scientific basis at a time when the use of networks is clearly expanding. In 2021, more than 4.26 billion people used social media globally, spending a mean of 144 minutes a day on social media and messaging services. This mark is projected to reach 6 billion people by 2027 (Dixon, 2022). Around 72% of the U.S. adult audience uses some social networks (Auxier & Anderson, 2021).

These data reflect a profound change in how we communicate, which can directly affect people's lives, influencing their decisions regarding their health (Luqmani & El Hashim, 2022; Park *et al.*, 2021). Park *et al.* (2021) argue that people who trust the information available on social networks are more reluctant to get vaccinated than those who rely on traditional media. However, social networks can also disseminate useful medical information (Katz & Nandi, 2021). The agility of this resource and the possibility of reaching a large audience are other factors that contribute to its use (Puri *et al.*, 2020).

Unlike news or entertainment content, in which such production is focused on communication companies, users produce the information that circulates on the networks (Manco Vega, 2021; Puri *et al.*, 2020). This is a particularity that, on the one hand, gives people a voice to express their visions about the world, and on the other hand, has transformed social networks into a setting for spreading disinformation and misinformation.

There is a variety of concepts related to disinformation, and there is no consensus among theorists on its definition. However, we have adopted the concept proposed by UNESCO (2018). Disinformation is typically used to describe intentional efforts to confuse or manipulate individuals by providing them with dishonest information (UNESCO, 2018). Disinformation[1] is typically employed to describe intentional efforts to confuse or manipulate individuals by providing them with dishonest information (Unesco, 2018). In other words, disseminating

[1] We prefer the use of 'disinformation' and 'misinformation' over 'fake news' because the term 'news' implies verifiable information of public interest, and any information that does not meet these criteria should not be considered legitimate news. In this context, 'fake news' is a contradiction in itself as it undermines the credibility of information that truly meets the standards of verifiability and public interest, which is what real news represents (Unesco, 2018).

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content manufactured to harm the reputation of an individual or institution (Wardle & Derakhshan, 2017; Tandoc Jr. *et al.*, 2019). This is often accompanied by parallel and intersecting communication strategies, as well as a range of other tactics such as hacking or compromising individuals. On the other hand, misinformation is generally used to describe misleading information that is created or spread without manipulative or malicious intent (Unesco, 2018). Both are problematic for society, but disinformation is particularly dangerous as it represents threat to democratic and can destabilize the society (McKay & Tenove, 2021). Frequent organization, ample resources, and reinforcement through automated technology are other factors that greatly amply its damage (Unesco, 2018).

This study will focus on the content generated on Twitter (rebranded as X since October 27, 2022), a microblogging platform established in 2006 characterized by short texts. Until 2017, tweets were limited to 140 characters, but since then, they have been extended to up to 280 characters or even more[2], allowing users to share photos and videos as well. It currently has 666 million monthly active users (Statista, 2023). It is worth noting that the countries with the highest number of users on this social network are the United States, Japan, Brazil, the United Kingdom and India (Trecebits, 2023).

While it may be one of the most widely used social media platforms globally, Twitter serves as a relevant case study for exploring public discourse on vaccines due to its frequent use as a platform for spreading disinformation and rapidly publishing content amidst (Heravi & Harrower, 2016; Singh *et al.*, 2020). Vosoughi *et al.* analyzed a dataset of rumor cascades on Twitter spanning from 2006 to 2017, where approximately 126,000 rumors were disseminated by around 3 million individuals. The authors found that false news reached a wider audience compared to the truth, reaching more people. Monaci (2021) highlights the fundamental role of Twitter in spreading various conspiracy theories, such as the flat Earth theory, the COVID-19/5G connection theory, and the anti-vaccine theory thus dramatically polluting the public sphere of social media. For instance, the author of the "Plandemic" video, which features various conspiracy theories, gained 130,000 followers in just one month after its release (The Verge, 2020).

Moreover, Twitter is recognized as the platform with the highest volume of health-related content (Manco Vega, 2021). Scientists and healthcare professionals extensively utilize Twitter as a platform for disseminating biomedical scientific information (Pershad *et al.*, 2018). On the other hand, in Italy, during March 2020, an average of 46,000 inaccurate news posts were being published on Twitter daily, all associated with misinformation and disinformation about the health crisis (Bruno Kessler Foundation, 2020). Taking this into consideration, Twitter offers a valuable resource for studying public discourse on vaccines.

Many studies have investigated the public discourse about COVID-19 vaccines on Twitter. For instance, Tomeny *et al.* (2017) investigated anti-vaccine beliefs in tweets published from 2009 to 2015 in United States. The authors found that half of the tweets contained anti-vaccine beliefs. On the other hand, studies that investigated tweets during the coronavirus pandemic phase focused primarily on sentiment analyses on vaccines (positive, negative, neutral) using machine learning techniques. Alam *et al.* (2021) identified neutral sentiment in most tweets, but the sentiment was not consistent over the period investigated; Ali *et al.* (2021) also found neutral sentiment in tweets related to COVID-19 vaccines in the United States, also showing that this sentiment changed according to the US state; Hu *et al.* (2021) identified an increase in positive and a decrease in negative tweets in the same country. Ansari and Khan (2021) analyzed tweets posted in several countries and found that sentiment was negative in most countries related to a lack of trust and fear of vaccines. Bi *et al.* (2021) found that attitudes

[2] Although most users now have 280 characters, since April 2023, this social network has offered the option of writing tweets with up to 10,000 characters for Twitter Blue subscribers through a payment system (*El Mundo*, 2023). Later on, this limit was expanded to up to 25,000 characters in the same year (HelpTwitter, 2023).

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about both negative and neutral vaccines oscillated over time. Bonnevie *et al.* (2021) suggest that those opposing COVID-19 vaccines on this social network encourage others to engage in the same behavior, fostering distrust *vis-à-vis* health authorities.

Additionally, only a few studies have specifically compared different periods of the public debate regarding this issue on Twitter, such as the pre-pandemic and pandemic periods. For example, Engel-Rebitzer *et al.* (2021) identified that American legislators participated less in the public discussion about vaccination before the arrival of SARS-CoV-2, changing their behavior with the pandemic, which could influence the acceptance of the COVID-19 vaccine among their followers. These findings suggest nuances in different epidemiological and social contexts, which may influence the discourses that circulate in social networks and, therefore, the public debate about vaccines. In turn, these possible discursive changes also imply modifications in people's reluctance to be vaccinated which would depend, importantly, on the context (Larson *et al.*, 2014).

Precisely, this study aims to address the existing gaps and the limitations in the literature by conducting a mixed methods analysis of two samples of tweets. There are two main reasons for using this approach: 1) most studies on vaccines have primarily focused on quantitative analysis using sentiment analysis on Twitter, often overlooking the qualitative aspect. By incorporating qualitative analysis, we can gain a more comprehensive understanding of the discourse surrounding vaccines; and 2) there is a lack of comparative studies in this field. By comparing two distinct periods, we can examine the similarities and differences in the discourses about vaccines. It is important to take into account the social context in which these discourses were produced, as it influences discursive practices. Drawing on discourse theory, we seek to understand how these discursive practices contribute to the construction of meaning (Araújo, 2007). In doing so, we situate our research within the broader context of existing research approaches.

Our main research questions are:

RQ1. How is public discourse on vaccines characterized before and during the COVID-19 pandemic on Twitter?

RQ2. What are the differences and similarities in public discourse on vaccines before and during the COVID-19 pandemic on Twitter?

RQ3. Has denialist discourse increased during the pandemic period on Twitter?

In this sense, to answer these questions, our work proposes to map comparatively the public debate on vaccines on Twitter during the pre-pandemic and pandemic periods, focusing on the discourse produced and characterizing the profile of users and tweets (content, vaccine, sources). However, the qualitative content analysis led us to focus on a relatively small sample of tweets. Although this allowed for a deeper exploration of the content, the representativeness of the results is limited, and the analysis should be regarded as exploratory.

1.1. *Discourse theory*

We define discourses "all manifestation or expression, verbal or non-verbal, of a social practice" (Rodrigues & Braga, 2014, p. 119), understood from the historical-social and ideological context of its interlocutors and the place from which they speak (Pêcheux, 1988). In other words, we are interested in analyzing this social practice in which Twitter users are involved, also considering what they say, how they say it, and with what approach.

Discourse analysis can also be considered a methodological, theoretical framework since operational categories of analysis have emerged from the discursive formation (Foucault, 1986). Discursive formations must be understood within a discursive space or field; in other words, they are always related to specific fields of knowledge. For example, in this study, when we speak of economic, political, and medical-scientific discourse (see discourse categories described in the methods section), we are referring to the fact that each comprises a set of statements based on a particular discursive formation; that is, economics, politics, science, or

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medicine. However, it does not mean that these formations are disciplines in itself but rather comprise a field of knowledge (Fischer, 2001).

The statement is characterized by four essential elements: a referent (a reference to something we identify), a subject (someone who can effectively affirm something, which in this study is the Twitter user), and the fact that the statement does not exist in isolation, but always in association and correlation with other statements of the same discourse (for example, political or economic discourse), and specific materiality; in other words, what is written, recorded in some type of material, subject to repetition or reproduction (Fischer, 2001). No discourse starts from scratch without precedent and consequences, each is part of a network of meanings, part of its production conditions (Araújo & Cardoso, 2007).

Communication relationships are always power relationships that depend, in form and content, on the material or symbolic power accumulated by the social agents involved in these relationships, which can allow the accumulation of symbolic power, which is the power to construct reality (Bourdieu, 1989).

Symbolic power can be considered "magical power" because other resources such as mobilization are appealed to instead of using force to obtain what is desired. It is based on the belief in the legitimacy of the words and those who pronounce them. Symbolic power is a transformed, transfigured, and legitimized form of other power forms: economic and social power are converted into symbolic capital through legitimation strategies. "Symbolic power is that invisible power that can only be exercised with the complicity of those who do not want to know that they are subject to it or even that they exercise it" (Bourdieu, 1989, p. 4).

In the case of the analyzed tweets, this symbolic power will be linked to a certain extent to the profile of the users and the sources cited since they are the ones that give legitimacy to the discourse on vaccines (people and institutions that participate in this symbolic market). In this game, social agents negotiate their way of perceiving the world and society. They negotiate their symbolic goods based on a game of forces and disputes over symbolic power (Araújo & Cardoso, 2007). However, symbolic power takes shape if social agents recognize a given discourse as legitimate through the power relationships that underpin this capital. The rules of legitimacy are socially determined by the contexts in which they operate and help to establish (Araújo & Cardoso, 2007).

Messages must circulate and become public to achieve some discursive power effectively (Bourdieu, 1989). This Bourdieusian concept highlights the strategies social network users adopt to gain legitimacy in the discourses on vaccines. Although these contributions do not have a direct translation to the variables that we have generated, they are helpful to 1) state that there are several dimensions (i.e., variables) of interest to understand the discourse on vaccines, and to 2) generate inductively (that is, without using a priori defined categories and considering the context and themes in our data) our variable "Discourse type."

2. Methods

2.1. *Data collection*

The choice to analyze Twitter was based on the criteria of relevance and data accessibility. A search was conducted through Twitter's "advanced search" tool to compose the sample, entering the following key words in English: vaccine, vaccines, vaccinating, vaccinated, vaccinate, vaccinates, vaccination, immunization, immunizate to get all the tweets that contain at least one of those words, and including the English language filter. Tweets published in the pre-pandemic period were retrieved from March to June 2019. This period coincides with several measles outbreaks in European countries and the United States. During the pandemic period, the tweets published from May to December 2021 and in January, March, and April 2022 were retrieved. In the first period, vaccination campaigns had already expanded to several European countries and the United States; in November 2021, the emergence of

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Omicron led to global uncertainty as authorities were initially unclear whether COVID-19 vaccines would be effective against this new variant. The second period continues with uncertainty about this variant, coinciding with the advancement of second booster campaigns in several countries. Collection days were randomly chosen in both periods. The data was extracted from the Twitter API using twarc2, a Python software tool. The access was obtained through the Twitter API Researcher Access application, which allowed access to content from previous years. However, we only accessed the history of public conversations.

A total of 236,536 tweets were downloaded in the pre-pandemic period and 340,396 in the pandemic period, totaling 576,932 posts. Retweets were excluded from this initial sample, and 51 tweets from the pre-pandemic period and 21 posts from the pandemic period were eliminated during the data cleaning process. 500 tweets of each period were finally randomly selected and manually and qualitatively coded. The exclusion criteria applied were tweets about animal vaccines, the use of the term "vaccine" as a metaphor, and when the content was written in another language, even if the keyword was written in English in the post. The final sample consisted of a thousand tweets. As the tweets were selected through simple random sampling, the sample size that we have allows us to obtain estimates with a margin of error of 3.1%, with a confidence level of 95% and assuming a population proportion of 50%. However, these calculations are based on the number of tweets that we were able to retrieve through the API (considering the pooled sample of both periods, that is, 576,932 posts), which are limited. Therefore, the margin of error that we have computed should be regarded as a lower bound of the imprecision of our estimates, as the total number of tweets in those periods is higher. So, the comparisons between periods should be taken with caution, especially when the percentages are close.

2.2. *Variables and Analysis*

We have conducted a qualitative-quantitative methodology through content analysis to explore the similarities and differences in the analysis that have emerged on the subject in Twitter. A content analysis applies categorization procedures and objectively identifies specific features within a text (Bardin, 2010). Two trained researchers performed the coding manually to compose the corpus of qualitative analysis. The tweets were thoroughly read and reread to identify patterns and similarities in their content and establish the categories of eight variables: User, content, objective versus subjective information, vaccine, pharmaceutical company, sources of information, and discourse.

Users were classified as anonymous (users who do not identify themselves or use their first name but without any other identification), general public (people who identify themselves through their full names, biography, or use a photo in their profile), health professionals, media and journalists (both journalists who represent their media outlet and when they speak for themselves). Other less frequent types of users, such as non-profit organizations, government organizations, government scientific organizations, scientific companies, and international scientific organizations, were included as "other," along with users who did not fall into any of the categories described above, e.g., deleted and suspended accounts.

The variable content includes the categories of experience or personal opinion, research results, resources for patients (posts with information on where to get vaccinated, places, and dates), advertising, news, experience related to the side effects of vaccines, and vaccination-related data. Tweets that did not fit into any of the described categories were grouped into others. The variable information classified tweets as objective (when the arguments are based on facts and data), or subjective (when the arguments are based on experiences and personal interpretations). We also identified the different diseases that are mentioned in the tweets (flu, COVID-19, measles, and the like) and the pharmaceutical company that was mentioned (if any).

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In relation to the variable source of information, we have coded the tweets into scientific sources (scientific organizations, professional associations, government scientific organizations, scientific companies, health professionals, university scientists, and scientific journals), or non-scientific sources (governmental organizations, non-governmental organizations, the media and journalists, consumer groups, and others, when they have not been included in any of the sources cited above) to analyze whether the tweet quotes a person or institution that provides some information related to vaccines.

Finally, the variable discourse has emerged from an inductive process in which statements with similar discursive characteristics were coded (see Table 1).

Table 1. Categories of analysis of discourses related to vaccines on Twitter.

Discourse[1]	Description of the categories.
Anti-denialist	Criticisms directed towards individuals who deny scientific facts and refuse to get vaccinated.
Denialist	Posts or comments where users deny scientific evidence or facts about vaccines.
Economic	Discussions focused on the economic aspects of vaccines, such as their cost, impact on the economy, or financial incentives.
Fear	Expressions of fear or concerns regarding vaccines and their potential adverse effects.
Gratitude	Comments expressing gratitude towards institutions, governments, or healthcare professionals for their efforts in vaccine development and distribution.
Institutional	Government-related data, information, or policies regarding vaccination, including legislative measures.
Motivational	Posts that aim to motivate or encourage people to get vaccinated.
Medical-scientific	Discussions that value scientific discoveries, research, or data related to vaccines, including how they work or their effectiveness.
Pandemic management measures	Discussions related to various measures taken to manage the pandemic, such as lockdowns, testing, contact tracing, and vaccine distribution.
Pharmaceutical	Information provided by pharmaceutical companies about vaccines or discussions defending the role of pharmaceutical companies in vaccine development.
Political	Discussions that link vaccines to political debates or express opinions of politicians on vaccination-related issues.
Preventive	Focuses on the benefits of vaccination in preventing illness, hospitalization, and death.
Protest	Posts or comments from individuals who are strongly indignant or angry about vaccination-related issues.
Protest and defiance/questioning	Users questioning or expressing defiance towards governments, institutions, or other individuals regarding vaccination-related matters.
Sarcasm/humor	Posts or comments that use sarcasm or humor to satirize government decision-making or any topic related to vaccines.

[1] The tweets that do not fit into any of the categories described were classified in the Others category.

Source: own elaboration.

An intercoder reliability assessment was conducted with a randomly selected 10% of the sample (O'Connor and Joffe, 2020) for the eight variables following the Gwet's AC1 statistical coefficient of concordance (Scannell *et al.*, 2021). After the first intercoder agreement assessment, a further round of coding training was done for the variable 'Discourse type' because it scored below the threshold of 0.6. The results of the reliability scores between the evaluators were statistically significant (see Table 2).

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Table 2. Results of the intercoder agreement test (Gwet's AC1).

Variables	Agreement
User	0.81
Type of content	0.71
Type of information	0.91
Type of vaccine	0.87
Pharmaceutical company	0.98
Sources	0.9
Type of discourse	0.79

Source: Own elaboration.

For the statistical analysis, we cross-tabulated all our variables with a dummy variable denoting the period (before and during the COVID-19 pandemic) to assess how much our variables of interest changed between periods. We performed chi-squared tests to check if the variables vary depending on the period considered in a statistically significant way (level of significance $p<0.05$).

In order to comply with ethical requirements, the project (anonymous), in which this study is nested, has been approved by the Ethical Committee of the University (anonymous) under the (anonymous) protocol and the analysis plan has been published in AsPredicted under code (anonymous).

3. Results

We have comparatively analyzed two periods marked by different epidemiological and social contexts to understand the similarities and differences in the public debate about vaccines on Twitter: the period before the pandemic (pre-COVID) and the pandemic period (during COVID). Cramer's V test computed for each variable (cross-tabulated with the period dummy) shows that some elements of the discourse changed more between periods, while others experienced small changes, yet others remained unchanged in a statistical significant way, as can be seen in Table 6. Mentions to specific vaccine, the type of discourse and content are the variables with higher differences between periods. On the other hand, according to our estimates, the type of information and sources were not significantly different between periods.

User profiles were similar in both periods, with a predominance of anonymous users (35.40% and 37.60%, respectively) and the general public (29% and 33%, respectively). However, we identified a lower proportion of the general public commenting on vaccines and fewer media outlets (3.40%) doing so in the pre-COVID period, as shown in Table 3. We have found more deleted and suspended accounts in this period, which explains the high number in the category other (26.20%). During the pandemic, we identified an increase in the proportion of the general public and, above all, the media and journalists (7.60%) posting about vaccines. Noteworthy is the low presence of tweets from health professionals in both periods. The same thing occurs, albeit more expressively, with government organizations, government scientific organizations, scientific companies, international scientific organizations, and non-profit organizations, which, for this reason, were also included under "other."

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Table 3. Twitter user.

Categories	Prepandemic	Pandemic	Total
Anonymous	177	188	365
	35.40	37.60	36.50
General Public	145	165	310
	29.00	33.00	31.00
Health professional	30	16	46
	6.00	3.20	4.60
Media and journalists	17	38	55
	3.40	7.60	5.50
Others	131	93	224
	26.20	18.60	22.40
Total	500	500	1000
	100.00	100.00	100.00

Pearson Chi2 = 20.35; Prob = 0.000. First row shows *frequencies* and second row shows *column percentages*

Source: Own elaboration.

Most tweets (70.60%) during the pre-pandemic refer to vaccines in general, with isolated tweets relating to specific vaccines, such as measles. However, during the pandemic, vaccines against COVID-19 were found in 84.60% of the posts. This constitutes the biggest change across periods. Although people comment on these vaccines more in this period, most do not refer to the pharmaceutical manufacturing companies. However, if we compare both periods, a slight increase in tweets that specifically mention these companies is observed during the pandemic against the pre-pandemic period.

The two periods are expressly marked by tweets with content related to opinions and personal experiences regarding the vaccines (63.20% and 65.40%, respectively), as shown in Table 4. Such messages are characterized, in general, by informality in how they communicate: the use of ellipses, words in quotation marks when trying to emphasize something, and the use of colloquial expressions, abbreviations, and swear words. Coinciding with this premise, we have also identified that most of the information provided in both periods is subjective; that is, it cannot be verified, such as cases of users who give their opinion about the fact that parents did not vaccinate their children and the consequences of this decision. However, tweets containing verifiable information represent one in four (pre-COVID) and one in five tweets (pandemic), without statistically significant difference between periods.

Table 4. Type of content.

Categories	Prepandemic	Pandemic	Total
Personal opinion or experience	316	327	643
	63.20	65.40	64.30
Research results	46	24	70
	9.20	4.80	7.00
Resources for patients	4	24	28
	0.80	4.80	2.80
Advertising	13	7	20
	2.60	1.40	2.00
News	71	69	140
	14.20	13.80	14.00

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Experience related to the side effects of vaccines	6 1.20	6 1.20	12 1.20
Affected by vaccination	9 1.80	3 0.60	12 1.20
Vaccination data	2 0.40	13 2.60	15 1.50
Other	33 6.60	27 5.40	60 6.00
Total	500 100.00	500 100.00	1000 100.00

Pearson Chi2 = 34.88; Prob = 0.0000. First row shows *frequencies* and second row shows column *percentages*

Source: Own elaboration.

Returning to the content (Table 4), the proportion of tweets addressing research results decreased in the pandemic period. On the other hand, posts related to patient resources have increased in the pandemic, with information on where to get vaccinated or how to make an appointment to get vaccinated. Tweets commenting on data related to vaccine coverage against COVID-19 have also increased, focusing, for example, on the pace of the vaccination campaign. The content related to the experience of side effects has remained low in both periods (1.20%).

Information sources are a category without any significant difference between the two periods. Most tweets do not cite any source (74.49% and 78.40, respectively), as shown in Table 5. Although the low presence of scientific and non-scientific sources is similar in the two periods, the type of source cited is different. In the case of scientific sources, in the pre-COVID period, the Centers for Disease Control and Prevention (CDC) is the source that was cited more than once. Scientific journals stand out in the pandemic period. However, they are not quoted regularly. Concerning non-scientific sources, the media appear timidly in both periods, such as the case of the Canadian Broadcasting Corporation (CBC) in pre-COVID and Fox and New York Times during the pandemic mentioned more than once. Although the frequency of consumer groups is low in both periods, it is worth noting that it is slightly more marked than in the previous period during the pandemic.

Table 5. Source of information.

Categories	Prepandemic	Pandemic	Total
Non-scientific source	96 19.75	89 18.31	185 19.03
Scientific source	28 5.76	16 3.29	44 4.53
No source	362 74.49	381 78.40	743 76.44
Total	486 100.00	486 100.00	972 100.00

Pearson Chi2 = 4.02; Prob = 0.1338. First row shows *frequencies* and second row shows column *percentages*

Source: Own elaboration.

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3.1. *Diverse discourses mark the two periods*

We have identified 15 discourses related to vaccines/vaccination that express different meanings on the topic, as seen in Table 6. During the pre-pandemic period, the polarization between denialist (13.20%) and anti-denialist (15.40%) discourses stands out. The first is made up of users who, for example, say that they have followed the doctors' guidelines but regret it because the vaccines have harmed their children. On the other hand, the anti-denialist discourse is formed by those who have criticized people who do not get vaccinated or are against vaccines. Such discourse emphasizes that the benefits of vaccination far outweigh their adverse effects. Some posts also demystify the relationship between vaccines and any disease or disorder they may cause in children. However, during the pandemic, the proportion of denialist (6.20%) and anti-denialist (6%) discourses is reduced compared to the previous period. The denialist discourse, in some cases, is sustained based on doubts about the quality or efficacy of vaccines against COVID-19.

Table 6. Type of discourses in both periods.

Categories	Prepandemic	Pandemic	Total
Denialist	66 13.20	31 6.20	97 9.70
Protest	7 1.40	11 2.20	18 1.80
Protest and defiance/questioning	47 9.40	39 7.80	86 8.60
Fear	5 1.00	5 1.00	10 1.0
Economic	5 1.00	4 0.80	9 0.90
Pharmaceutical	9 1.80	17 3.40	26 2.60
Sarcasm/humor	19 3.80	13 2.60	32 3.20
Political	31 6.20	22 4.40	53 5.30
Institutional	15 3.00	14 2.80	29 2.90
Pandemic management measures	0 0.00	102 20.40	102 10.20
Medical/scientific	89 17.80	50 10.00	139 13.90
Preventive	39 7.80	63 12.60	102 10.20
Motivational	34 6.80	40 8.00	74 7.40
Anti-denialist	77 15.40	30 6.00	107 10.70
Gratitude	3 0.60	3 0.60	6 0.60
Other	54 10.80	56 11.20	110 11.00
Total	500	500	1000
	100.00	100.00	100.00

Pearson Chi2 = 159.28; Prob = 0.0000. First row shows *frequencies* and second row shows column *percentages*

Source: Own elaboration.

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Nevertheless, the discourse that has stood out the most during the pandemic is related to pandemic management measures (20.40%). Users comment on the vaccination plans, the groups that should be vaccinated and the order, the mandatory nature of vaccines, the vaccine passport, and other measures such as the mandatory use of masks even after vaccination.

The posts based on inquiries remain at similar levels in the two periods (9.40% and 7.80, respectively). They question, in general, the government's measures, the institutions, and other people's decision-making regarding vaccines. The institutional (3% and 2.80%, respectively) and motivational discourses (6.80% and 8%, respectively) were not very frequently adopted in the two periods. The first is made up of posts that talk about governments and legislation data/information, and the second consists of users who share their personal experience of what it has been like to get vaccinated, posting photos of when they received the dose, some with a smile on their face, or making a positive sign. Although this study does not aim to analyze emojis, we have observed the presence of messages accompanied by emojis of injection, positive thumb sign, smile, and applause in motivational.

The preventive discourse which mainly focuses on vaccination benefits, has increased during the pandemic (12.60%). However, during this same period, we identified a decrease in the medical-scientific discourse, in which scientific facts on the vaccines are valued (10%). The use of sarcasm/humor (e.g., when users satirize government decision-making or any vaccine-related topic) was seldom used during the debate on Twitter in both periods (3.80% and 2.60, respectively). On the other hand, the pharmaceutical discourse, which comprises information about vaccine-producing pharmaceutical companies, or defend these companies, increased during the pandemic (3.40%).

Other discourses in the tweets were related to protest (people who are angry with vaccination-related issues); fear (fear towards vaccines). We also found economic (focus on economic issues related to vaccines), political (linking vaccines to political debate) and gratitude (focus on acknowledgments to institutions/governments/health professionals for their vaccine-related work) discourses. The tweets that do not fit into any of the categories described were included in the other category.

4. Discussion and conclusion

This study has comparatively investigated the discourses on Twitter during the pre-pandemic and pandemic period and characterized the profile of the users, content, vaccine types, and the sources of information. To this end, we have qualitatively analyzed a random sample of tweets from each period following a manual coding.

One of the most interesting findings was that despite the emergence of the pandemic and the subsequent vaccination campaigns twitter users from the medical-scientific sphere did not have a more active role in the debate in this social media platform. This situation contrasts with what is advocated by some authors who consider that the active presence of health professionals in social networks could be a way of disseminating reliable health-related content, despite some ethical dilemmas over their presence in networks (Ventola, 2014; Grace, 2021; Berro, 2021; Wahbeh *et al.*, 2021).

The media and journalists were already very active during the pandemic by disseminating information and issuing vaccine opinions, reflecting their essential role in health crises. As Lyu *et al.* (2021) emphasize, the public debate of the COVID-19 vaccine has mirrored the news topics in the mainstream media. As highlighted by Aleixandre-Benavent *et al.* (2020), information professionals can play an important role in debunking misinformation. This is only viable if they filter out what is unreliable, offering quality information to their audience. Moreover, they have been responsible for managing pandemic-related scientific information, which during this period has grown fast.

The predominance of subjective content on Twitter is similar to the findings of Lyu *et al.* (2021), whose opinionated tweets related to vaccines were the most retweeted and commented

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on. This fact reinforces the perception that government and scientific institutions must understand what type of message can reach people more easily. In other words, it is necessary to use communication with which people indeed identify, which is more emotional. Anti-vaccine groups employ this strategy: the use of false or doubtful information is based on emotions to reach people, spreading fear of vaccines (Johnson *et al.*, 2020; Ghanem *et al.*, 2020), and the continuous use of false information implies that it becomes true for a specific group of people (Greene & Murphy, 2021).

This subjective nature is also perceived by the low use of information sources to support opinions on vaccines, and when cited, non-scientific sources prevailed, as in the case of the media. The presence of television channels, such as Fox News, can be an indication of conservative ideas on vaccines. According to a national survey in the United States by Ruiz and Bell (2021), those who preferred Fox News and social networks had less intention to vaccinate against COVID-19.

The discourses circulating about vaccines on Twitter are disputed for their legitimacy in this symbolic and virtual market and are, thus, based on several discursive formations. The management measures, for example, break with the existing pre-pandemic discourse as they have revealed all the knowledge related to the administration of the pandemic, centralizing the debate on decision-making regarding vaccines and other health measures.

The conflict between those who trust scientific evidence and criticize others who do not adhere to it and those who rely on misinformation to support their skepticism regarding vaccinations is demonstrated by the polarity between the denialist and anti-denialist discourses between the two periods. The polarity on the subject has already been recorded in the literature. Lyu *et al.* (2021) found that socioeconomically disadvantaged groups were likelier to have polarized views on COVID-19 vaccines on Twitter, either for or against the vaccine. Hu *et al.* (2021) believe that social media platforms with large numbers of users have disrupted the traditional communication of vaccine information, allowing anti-vaccine people to spread misleading messages to a specific audience whose views on vaccination might be subject to change.

Our findings show that the denialist discourse decreased during the coronavirus pandemic. However, as Greene and Murphy (2021) point out, we should consider that a single exposure to false health information can influence people's behavior. Besides of this, the denialist discourse can be understood as a counter-discourse, based on concept of counter-power (Foucault, 1986), in the sense that it is shown as a resistance to the exercise of power by health institutions that dictate the perception of what it is to be sick or healthy (Costa & Alves, 2019). Constantinou (2022) argues that the governments' efforts to contain the coronavirus pandemic have deployed dominant discourses to control the population. Given that part of the discourses about vaccines express different degrees of doubt, it would be interesting to come up with more inclusive strategies (that focus more on vaccine hesitation).

Although the type of content has practically not changed between the two periods, different events marked the debate on vaccines in the pre-COVID period; for example, the low vaccination coverage against measles in the U.S. and European countries and the attacks on the mandatory nature of vaccines, compared to the pandemic period in which the core subject of the discourses was about vaccines against COVID-19. In this sense, in the pre-COVID period, the discourse on vaccines has been fragmented due to the diverse topics it covers, which could represent a negligible impact on the public debate on the subject if compared to the COVID-19 period.

The presence of tweets with motivational discourse is interesting given its potential to be part of more effective communication initiatives. As Ittefaq *et al.* (2021) point out, based on the theory of normative behavior, people are motivated by what other people do. The authors suggest that using selfies related to the administration of COVID-19 vaccines may be a positive public response to vaccinations on social networks. In search of more effective communication,

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it would also be relevant for health institutions to consider the socio-cultural, political, and geographic contexts of users to disseminate specific interventions on vaccines in social networks so that they consider the needs of the population (Miyake & Martin, 2021; Tomeny *et al.*, 2017).

However, our study has several limitations. The most important one is the sample size, which impedes us to accurately assess geographical differences across English-speaking countries or to explore differences within each of the two time periods. In that sense, the results pertain to the specific time periods that were analyzed. Namely, in the case of the COVID-19 pandemic we cover the period that coincides with the initial and middle phases of vaccination campaigns in English-speaking countries. Moreover, it is important to also bear in mind that the estimates obtained with our sample have a margin of error of at least 3.1 percentage points for the level of confidence of 95%. Although our sample allowed us to explore different types of discourses (and other discursive attributes) of the vaccine-related content with nuance, the level of imprecision of our estimates forces us to be cautious in our conclusions of the change across periods and means that the present analysis is exploratory. Second, the analysis focused only on textual content, and it would be relevant for future studies to investigate the memes, photos, and videos published on Twitter, considering the vital role of the visual in the communication process. More than 50% of the content on this platform, for example, features images and videos (Ortiz-Ospina, 2019). Secondly, we have randomly selected tweets, but it would be interesting to focus on the most impacting tweets in future analyses since they may be those with the most significant capacity to shape public discourse and influence the opinions of Twitter users. In addition, another issue that may deserve a more profound analysis is the scope and characteristics of specific hoaxes and disinformation about vaccines. In addition, while tweets in English may represent an English-speaking community sharing content and interacting, not considering the specific geographic location limits our analysis. Each country has different social characteristics, health policies, and vaccination coverage that would help contextualise the discourses produced on Twitter. We would also like to address the technical limitations of APIs that researchers should be aware of. Some of these limitations include rate limits, data quotas, data quality, limited functionality, security concerns and privacy issues, among others (Janetzko, 2016). In the case of this study, we encountered access limitations, as we were unable to access accounts with private profiles. This represents constraints that could also impact data collection and the scope of the analysis. Furthermore, it is important to highlight that these limitations might have impacted the representativeness of the sample and the interpretation of the results.

Finally, despite the importance of Twitter in the stimulation of public discourse and debate about vaccines, our research did not include other important social media platforms such as Facebook, TikTok, or Instagram, which are also very popular. Therefore, in future research, it would be relevant to include other social networks in the analysis, to explore discursive differences across platforms. Despite these limitations, our study offers a relevant comparative view through a quantitative-qualitative content analysis, including a manual coding, to analyze public discourse and the characteristics of the content that circulates on social networks about the vaccines, helping us to understand the pandemic's impact.

Our results show that some discursive elements (especially the discourse) changed in line with the modified context since the COVID-19 vaccines came to the fore along with the other pandemic management measures. However, other variables related to the public discourse remained almost unchanged, most probably because the dynamics of the debate in Twitter were not highly impacted by the COVID-19 pandemic.

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