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# VACCINES ON YOUTUBE IN BRAZIL:

## an exploratory study using Natural Language Processing

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**ABSTRACT** – YouTube has emerged as a pivotal platform for health communication, particularly during global crises. This study analyzes 19.031 vaccine-related videos posted on YouTube in Brazil during the first two years of the covid-19 pandemic, using Natural Language Processing to examine video frequency, key actors, and main topics. Video production increased during major events, with an emphasis on health and political discussions. Media outlets, government organizations, and health professionals were the primary publishers, focusing on vaccination campaigns and scientific information. While reliable content dominated, discussions about misinformation and vaccine skepticism emerged as relevant topics, reflecting concerns over public perception. While the platform played a central role in disseminating reliable content, the visibility of controversial discussions highlights the complexity of digital health communication. These findings underscore the need for strategic communication approaches and platform policies that enhance authoritative health content while addressing challenges related to the spread of misleading narratives.
**Key words:** Vaccine. Covid-19. YouTube. Science communication. Natural Language Processing.

## VACINAS NO YOUTUBE NO BRASIL: um estudo exploratório utilizando Processamento de Linguagem Natural

**RESUMO** – O YouTube se tornou uma plataforma fundamental para a comunicação em saúde, especialmente durante crises globais. Este estudo analisa 19.031 vídeos relacionados a vacinas postados no YouTube no Brasil durante os dois primeiros anos da pandemia de covid-19, utilizando Processamento de Linguagem Natural para examinar a frequência dos vídeos, os principais atores e os temas centrais. A produção de vídeos aumentou durante eventos importantes, com ênfase em discussões sobre saúde e política. Veículos de mídia, órgãos governamentais e profissionais de saúde foram os principais responsáveis pelas publicações, focando em campanhas de vacinação e informações científicas. Embora o conteúdo confiável tenha predominado, debates sobre desinformação e ceticismo em relação às vacinas surgiram como temas relevantes, refletindo preocupações sobre a percepção pública. Embora a plataforma tenha desempenhado um papel central na disseminação de conteúdo confiável, a visibilidade de discussões controversas destaca a complexidade da comunicação digital em saúde. Esses achados ressaltam a necessidade de estratégias de comunicação e políticas de plataforma que fortaleçam conteúdos de saúde confiáveis, ao mesmo tempo em que enfrentam desafios relacionados à disseminação de narrativas enganosas.
**Palavras-chave:** Vacina. Covid-19. YouTube. Divulgação científica. Processamento de Linguagem Natural.

## VACUNAS EN YOUTUBE EN BRASIL: un estudio exploratorio utilizando Procesamiento de Lenguaje Natural

**RESUMEN** – YouTube se ha convertido en una plataforma clave para la comunicación en salud, especialmente durante crisis globales. Este estudio analiza 19.031 videos relacionados con vacunas publicados en YouTube en Brasil durante los dos primeros años de la pandemia de covid-19, utilizando Procesamiento de Lenguaje Natural para examinar la frecuencia de los videos, los actores clave y los principales temas. La producción de videos aumentó durante eventos importantes, con énfasis en discusiones sobre salud y política. Los medios de comunicación, las organizaciones gubernamentales y los profesionales de la salud fueron los principales emisores, centrándose en campañas de vacunación e información científica. Si bien el contenido confiable predominó, las discusiones sobre desinformación y escepticismo frente a las vacunas surgieron como temas relevantes, reflejando preocupaciones sobre la percepción pública. Aunque la plataforma desempeñó un papel central en la difusión de contenido confiable, la visibilidad de debates controvertidos resalta la complejidad de la comunicación digital en salud. Estos hallazgos subrayan la necesidad de enfoques estratégicos de comunicación y de políticas en la plataforma que refuercen el contenido de salud autorizado, al tiempo que aborden los desafíos relacionados con la propagación de narrativas engañosas.
**Palabras clave:** Vacuna. Covid-19. YouTube. Comunicación de la ciencia. Procesamiento de Lenguaje Natural.

## 1 Introduction

In recent years, YouTube has become established as an important media arena for disseminating information about science (Allgaier, 2020; Welbourne & Grant, 2016). Specifically in the area of health communication, studies show that the digital video-sharing platform has been widely used as a source of information about diseases such as the flu (Hernández-Garcia & Giménez-Júlvez, 2021), Zika (Bora et al., 2018; Kaiser et al., 2021), and HPV (Kim et al., 2021; Di Spirito et al., 2023).

However, the digital landscape is characterized by an overwhelming amount of information, making it increasingly difficult for users to discern credible sources from misleading content (Vosoughi et al., 2018). The rapid spread of misinformation and disinformation on social media platforms poses a critical challenge, especially in public health contexts, where access to accurate information can influence individual and collective decision-making (Wardle & Derakhshan, 2017). This phenomenon was particularly evident during the covid-19 pandemic, a period marked by a surge in digital content about the disease, including both scientifically grounded information and misleading narratives (Santos, 2021; Lopes & Brotas, 2024).

During the covid-19 pandemic, YouTube became one of the leading spaces for the dissemination of information about the disease (Basch et al., 2021; Chan et al., 2021). It was widely used by educators, researchers, media outlets, institutions, and science communicators as the main channel to discuss technical and scientific aspects of the SARS-CoV-2 coronavirus, prevention strategies, forms of treatment, vaccination, and to describe advances in scientific research and development (Allgaier, 2020; Massarani et al., 2020; Silva et al., 2020). However, this period was also marked by the spread of dis- and misinformation, and conspiracy theories on social media platforms, including YouTube (Santos, 2021; Lopes & Brotas, 2024). Misinformation refers to false or misleading information shared without harmful intent, whereas disinformation is deliberately created and spread to deceive or manipulate public opinion (Wardle & Derakhshan, 2017). The issue has been linked to both algorithmic biases in recommendation systems and the actions of anti-vaccine movements that capitalize on post-truth dynamics to spread misleading content (Costa et al., 2020).

YouTube has also emerged as a highly relevant platform for the circulation of videos in which media outlets and public bodies


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published news and announcements to keep the population informed about the production and distribution of vaccines, including epidemiological bulletins, vaccination calendars, and vaccination progress (Marchal & Au, 2020; Melo & Chagas, 2022). Furthermore, YouTube was widely used to share information on national and international institutional matters, such as decisions by the Executive, Legislative, and Judiciary branches, and statements and guidelines from international organizations, for example, the World Health Organization (Bravo et al., 2021; Monari & Bertolli Filho, 2019). On YouTube, information about vaccination was also especially relevant for specific groups, such as pregnant women, children, the elderly, and indigenous people (Lima et al., 2021; Magalhães & Rossi, 2023; Silva et al., 2020; Suárez-Mutis et al., 2022).

In this context, researchers have sought to understand how such subjects circulate on the platform. One approach consists of content analysis to identify the themes of vaccine-related information published on YouTube (Basch et al., 2017; Marwah et al., 2021). Some studies focus on user behavior and the analysis of comments posted on the platform (Silva et al., 2023). Others have focused on understanding the structure of the platform, especially its recommendation algorithm, which directs user behavior (Abul-Fottouh et al., 2020). Some findings indicate that the quality of information is low, raising concerns for public health authorities (Chan et al., 2021).

Most of these studies have been conducted in the Global North, with content analysis in English. Only a few investigations have been carried out based on YouTube in Brazil (Fonseca & d'Andréa, 2020; Brotas et al., 2021a, 2021b; Ortiz-Sánchez et al., 2020). From a methodological standpoint, a large part of the research is based on case studies or small samples of videos or channels (Carvalho et al., 2021; Kleina & Sampaio, 2021). The large volume of data circulating on the platform can pose additional challenges to researchers, requiring the use and development of automated tools and methods that can process large quantities of information, enabling broader analyses.

Given this scenario of competition for attention and a digital context in which the large volume of data offers both a possibility and a challenge, this exploratory study seeks to contribute to the understanding of how the topic of the vaccine was addressed on YouTube by different actors during the first two years of the covid-19 pandemic in Brazil. Our research questions below derive from this overall objective:

a) How often was the subject of vaccines addressed in videos posted on YouTube in Brazil in 2020 and 2021?

b) Who talks about this subject in their videos?

c) What vaccine-related topics were addressed in these videos?

d) How often were these topics discussed over two years?

e) Which topics were discussed with greater or lesser frequency by the different actors?

To deal with the large number of publications posted during this period, we adopted a mixed-methods approach, combining both quantitative and qualitative analyses. This methodological strategy includes the use of computational tools for data collection, the development of an algorithm for classifying actors, and the use of state-of-the-art Natural Language Processing (NLP) to analyze the titles of 19.031 videos that make up our sample. In this regard, the study also contributes to the methodological advances through the application of modern computational tools and techniques that are still little explored in communication studies in Brazil, and more specifically, in research on science communication.

## 2 YouTube and the circulation of information and misinformation about vaccines

YouTube is the social media platform with the second-largest number of active users in the world (Dixon, 2024). The platform has more than 2.4 billion registered users, second only to Facebook, which has 3 billion. In Brazil, YouTube has 144 million users, also ranking in second place after WhatsApp (We Are Social, 2024). The survey "What do young Brazilians think of science and technology?" shows that YouTube ranks second place among the social media platforms most widely used by people between 15 and 24 years old to access Science and Technology (S&T) content, cited by 73% of respondents (the first was Google) (Massarani et al., 2021).

The popularity of YouTube in Brazil underscores the importance of the video-sharing platform in the circulation and consumption of information about science and health, which intensified dur-


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ing the covid-19 pandemic. During the most significant public health crisis in recent years, YouTube was used to address technical and scientific topics that generally circulate only in highly specialized spaces, such as the characteristics of the coronavirus and the induction of immunity through different types of vaccines (Kohler & Dietrich, 2021; Pattier, 2021). Given the need to adopt social isolation measures to prevent the spread of the disease, including lockdown, the platform also became known for hosting so-called lives – live broadcasts in which the public could interact (Basch et al., 2021; Marwah et al., 2021).

Notwithstanding the above, the dynamics of the platform also enable the circulation of disinformation, transforming it into a space for the dissemination of conspiracy theories and pseudoscience (Brotas et al., 2021b; Machado et al., 2020; Massuchin & Santos, 2021; Oliveira, 2020). The spread of dis- and misinformation generates distrust in vaccines and compromises public health actions (Galhardi, 2022; Garcia et al., 2021), especially in a context in which the politicization and ideological instrumentalization of scientific information were decidedly present, as in Brazil. Political representatives, such as Brazil's former president Jair Bolsonaro, took a public stance against covid-19 vaccination, questioning the effectiveness of vaccines even in the face of scientific evidence and defending the non-mandatory nature of vaccination (Duarte & César, 2021; Fonseca, 2022; Kleina & Sampaio, 2021), using these issues to challenge political opponents and garner electoral support.

Specifically concerning the vaccine – the object of this study –, studies explored ways in which vaccine information is consumed and spread on YouTube. Some studies are user-oriented, through focus groups using videos published on the platform (Jennings et al., 2021), questionnaires to understand information consumption (Harrison et al., 2016; Robichaud et al., 2012), and analysis of comments posted on publications (Silva et al., 2023). Other investigations focus on the structure of the platform itself, particularly based on the analysis of the recommendation system (Abul-Fottouh et al., 2020), seeking to understand the algorithmic targeting of vaccine-related topics. Content analysis has also been used, based on the collection and analysis of videos about vaccination (Basch et al., 2017; Chan et al., 2021; Marwah et al., 2021).

However, such studies underline YouTube's positive potential for providing information about vaccination, highlighting the need

for closer collaboration with public health institutions (Basch et al., 2017). Some findings also reveal the low quality of information available on YouTube about immunization agents (Chan et al., 2021; Marwah et al., 2021), raising an alert to public health authorities. Educational channels, especially those under the responsibility of medical professionals, tend to offer more reliable information (Chan et al., 2021), but other spaces tend to disseminate misleading information or fail to provide satisfactory content.

In Brazil, one of the topics covered in research on vaccines on YouTube pertains to misinformation – considered a major problem faced by the platform –, including science denialism and the anti-vaccine movement (Ortiz-Sánchez et al., 2020), and the possible correlation between misinformation circulating online and new outbreaks of previously controlled diseases, such as measles (Benecke & DeYoung, 2019).

Other lines of investigation include topics such as the authoritative discourse of the Brazilian political right on the platform (Kleina & Sampaio, 2021), the influence of YouTube on public health decisions (Costa et al., 2020), the relationship with algorithmic governance (Fonseca & d'Andréa, 2020), platform moderation with respect to anti-vaccine content (Locatelli et al., 2022), and mediation of channels and influencers (Brotas et al., 2021a).

The main findings point to a concern about the regulation of social media, with the discovery that YouTube's removal of content involving misinformation and conspiracy theories is insufficient. One of the examples during the pandemic was the encouragement of alternative treatments for covid-19, such as hydroxychloroquine (Locatelli et al., 2022). Although this type of content is small compared to content about vaccination, it garners widespread engagement by numerous followers who identify with it (Costa et al., 2020). One of YouTube's actions in tackling this issue was to control the monetization system through algorithms. In mid-2020, as the pandemic worsened, the platform adopted a stricter funding policy, seeking to cut revenue to channels that spread disinformation. As a result, the search for terms such as "vaccine" has become more circumspect (Fonseca & d'Andréa, 2020), highlighting more recent videos produced by accredited institutions, to the detriment of independent channels.

Despite the growing international attention to the role of social media platforms like YouTube in spreading health-related misinformation, studies focusing on the Brazilian context remain limited.


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While existing research has explored the dissemination of misinformation and alternative treatments, there is still a lack of comprehensive analysis of how different actors – such as government agencies, media outlets, health professionals, and independent creators – have approached the topic of vaccines during the covid-19 pandemic. Moreover, few studies in Brazil employ computational methods to systematically analyze large datasets of online content. In Brazil, researchers have utilized BERT and its variations, such as BERTimbau, to investigate public perceptions and discourse on vaccination through social media platforms. For instance, BERTopic has been employed to compare pro- and anti-vaccination stances in Brazil and the United States, revealing that Brazilian anti-vaccine sentiment is often politically motivated rather than centered on health concerns (Sousa & Becker, 2022). Additionally, BERT-based stance classification models have helped identify influential words in vaccination debates, distinguishing between those who oppose vaccines in general and those specifically against Coronavac, a Chinese vaccine (Sáenz & Becker, 2021). These studies highlight the role of political polarization in shaping vaccine hesitancy and the effectiveness of BERT in uncovering underlying trends in public discourse (Lopes et al., 2023).

Our study seeks to contribute to these efforts by providing a mixed-methods analysis of vaccine-related content on YouTube, focusing on the diversity of actors involved, the topics addressed, and the evolution of these discussions over time. By doing so, it not only contributes to the understanding of science communication in digital environments but also advances methodological approaches in Brazilian communication research.

## 3 Methodology

The purpose of this study is to understand how the topic of the vaccine was addressed on YouTube by different actors during the first two years of the covid-19 pandemic in Brazil. Because this research was exploratory and longitudinal, we sought to outline as comprehensive a corpus as possible, reducing sample sizes. This study therefore employs mixed methods, with a qualitative-quantitative approach, and uses computational resources for data collection, processing, and analysis.

## Data collection and refinement

The composition of the corpus began with the collection of videos using YouTube Data Tools (Rieder, 2022), based on a predefined set of keywords and their variations: vaccine, vaccines, vaccinated, vachina, vaccination, vaccinal, v4c1n4, coronavac, pfizer, janssen, and astrazeneca. The search covered the period of January 1, 2020 to December 31, 2021 – the first two years of the covid-19 pandemic. A collection was carried out for each descriptor, making an initial total of 703.514 videos, whose metadata was stored on a spreadsheet.

We acknowledge that this methodological approach, like any other, has inherent limitations. The reliance on specific keywords means that videos discussing vaccines without including these terms in their titles or metadata might not be captured. However, this set of keywords has been consistently employed in our studies analyzing vaccine-related discourse across various media platforms (Fernandes de Oliveira et al., 2023a, 2023b; Soares et al., 2023). Our research has demonstrated that these keywords effectively capture a comprehensive and representative sample of online discussions about vaccines.

To refine the dataset, several filtering steps were applied. Duplicates (i.e., the same video collected more than once), videos from YouTube channels outside Brazil, and those addressing topics unrelated to vaccines were removed, resulting in a final sample of 67.674 videos.

## Classification of channels into profiles

Since one of the study's objectives was to identify the actors involved in the production and circulation of information about vaccines on YouTube, it was necessary to classify the channels on which the videos were published according to their profiles. While YouTube Data Tools provides metadata on channel categories – such as People & Blogs, News & Politics, and Entertainment – these user-defined labels did not align with our research needs. Consequently, we developed a classification algorithm called ProfileNER-classifier[1], which employs a hybrid approach combining rule-based methods with NLP techniques. The classifier operates based on the description provided by the channel owner, as this is the available metadata that indicates how the channel presents itself. However, this reliance on


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self-reported descriptions represents a limitation, as not all channels include sufficient information, and some descriptions may be ambiguous or misleading.

To enhance classification accuracy, the algorithm utilizes a dictionary of keywords and patterns derived from a large-scale Twitter dataset on vaccines, consisting of 13.2 million tweets. This dataset was gathered in a previous study conducted by the researchers, which analyzed vaccine-related discourse on social media (Lopes et al., 2023). By leveraging this extensive dataset, we identified frequently occurring terms associated with different actor profiles, ensuring that the classifier captured a broad and relevant range of descriptors. The final classification includes eight predefined actor categories: politician, media outlet, health professional, science (individuals with scientific or academic backgrounds), education professional, artist, organization, and journalist.

The algorithm applies pattern matching to detect these curated terms within each channel description. Given that some channels lacked descriptions or did not contain enough identifiable terms, they could not be classified by the algorithm. As a result, the dataset was reduced to 21.361 videos, ensuring that only channels with a clear actor classification were included in the final analysis.

## Data preprocessing

Initially, we performed experiments analyzing video transcriptions, collected with YouTube Transcript/Subtitle API tool. However, the results were almost uniformly poor, largely due to the low quality and fragmented structure of these transcriptions. In cases where users did not upload their own subtitles, the API relied on YouTube's automatic transcription system, which often produced highly truncated, error-prone text, making it nearly impossible to apply reliable computational analysis techniques. Given these issues, we decided to focus on video titles as the primary unit of analysis. Titles, while shorter, tend to be more concise, structured, and reflective of the video content, providing a more consistent basis for automated text analysis. Once again, we acknowledge that this approach assumes that titles are descriptive, clear, and correspond to the actual content of the videos, which may not always be the case. Despite this limitation, analyzing video titles has been an alternative employed

in other studies to extract meaningful insights (Porreca et al., 2020; Kim & Kim, 2022).

The video titles underwent a text preprocessing phase, mostly to remove frequent expressions and texts that contained only three words or fewer, to prevent bias in the automated analysis. Thus, we reached the final number of our corpus, consisting of 19.031 videos.

## Analysis

To analyze these more than 19 thousand titles, we used an unsupervised machine learning model – a type of artificial intelligence (AI) algorithm that operates on unlabeled data, i.e., without explicit guidelines about what should be predicted or inferred. These models seek to autonomously identify intrinsic patterns, structures, or clusters in data. We opted for the BERTopic algorithm (Grootendorst, 2022), an advanced topic modeling technique that uses state-of-the-art NLP. The tool uses BERT (Bidirectional Encoder Representations from Transformers), a language model that extracts the context of words in a text much more efficiently. Thus, BERTopic enables the discovery of topics with finer nuances and the extraction of complex relationships between words.

Although BERTopic is an automated topic modeling tool, its outputs require careful human interpretation to ensure meaningful and reliable results. The process is inherently qualitative, demanding that researchers immerse themselves in the corpus to derive insights from the computational outputs. To achieve this, a series of meetings were held where the research team systematically examined the model's results, refining topic categorizations and ensuring coherence in the interpretation of themes. As is common when using BERTopic (Grootendorst, 2022), extensive experimentation was required to determine appropriate hyperparameters. After multiple iterations, we set the model to generate 25 initial topics, with a minimum of ten videos per topic – parameters that provided a balance between granularity and interpretability. It is important to highlight that BERTopic does not assign names to the topics it generates; this task was exclusively performed manually by the researchers, who analyzed the most prominent keywords and representative video titles within each cluster to define meaningful and accurate labels.


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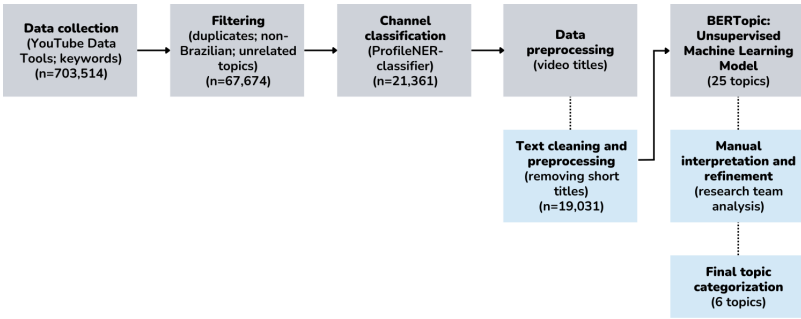
Following this interpretive process, some of the 25 initial topics were merged based on their semantic proximity, requiring the algorithm to recalculate topic distributions accordingly. This refinement step allowed for a more coherent categorization of the dataset, ultimately leading to the definition of six final topics: Vaccination Campaigns; Vaccine (Production, Commercialization, and Distribution); Politics; Adverse Reactions or Side Effects; Disinformation and Denialism; and New Vaccine (HIV and Malaria). The next section describes the results of this protocol. Figure 1 illustrates the methodological pipeline used for processing and categorizing YouTube video titles using BERTopic.

**Figure 1**

*Workflow for topic classification of YouTube videos*

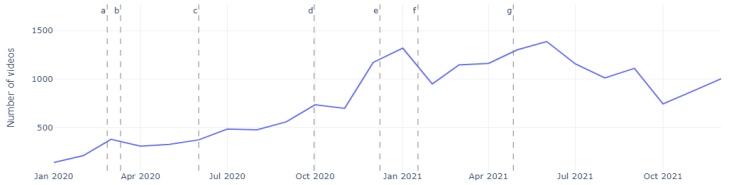



## 4 Results

Based on the collected and preprocessed data, we analyzed and visualized the monthly frequency of Portuguese-language YouTube videos addressing the topic of vaccines during the first two years of the global health crisis caused by covid-19. Figure 2 presents the upward trend in publications throughout 2020 and 2021, highlighting how the subject gained prominence as the crisis unfolded. Notably, the monthly number of publications surpassed one thousand videos during much of the second year of the pandemic.

**Figure 2**

*Number of videos about the vaccine posted per month (2020-2021)*




a) 26/02/2020: first recorded case of covid-19 in Brazil.
b) 11/03/2020: WHO declares covid-19 a pandemic.
c) 01/06/2020: signing of the contract between Fiocruz (Brazil) and AstraZeneca (U.K./Sweden) to produce the vaccine once available.
d) 30/09/2020: signing of the contract between Instituto Butantan (Brazil) and Sinovac (China) to produce the vaccine once available.
e) 08/12/2020: start of vaccination worldwide (U.K.).
f) 17/01/2021: start of vaccination in Brazil (São Paulo).
g) 27/04/2021: establishment of the Parliamentary Inquiry Committee, a temporary investigative body of the National Congress of Brazil, to examine the government's handling of the covid-19 crisis.

Source: YouTube. Generated by Authors.

A more in-depth analysis indicates that this upsurge occurred at the turn of the year – between November (698 videos) and December 2020 (1.173 videos), reaching the first peak in January 2021 (1.321 videos). In order to make inferences, we list some of the main events pertaining to the pandemic and the vaccine in the analyzed period, highlighted on the dotted lines in figure 2. Although it is outside the scope of this study to establish a statistical correlation between these variables, the quantitative data suggests an increase in content production on YouTube based on the news of the first person in the world to be vaccinated against covid-19, on December 8, 2020 in the United Kingdom (Murray, 2020) (see figure 2(e)), followed by the start of vaccination in Brazil, on January 17, 2021 (Amâncio, 2021) (see figure 2(f)).

After this period, focus on the subject recommenced starting in March 2021. In the following month, discussions about vaccination problems in Brazil would take on even more political aspects, with the establishment of a Parliamentary Committee of Inquiry on April 27, 2021, to investigate irregularities in the purchase of vaccines by the federal government (Folha de S.Paulo, 2021). While it is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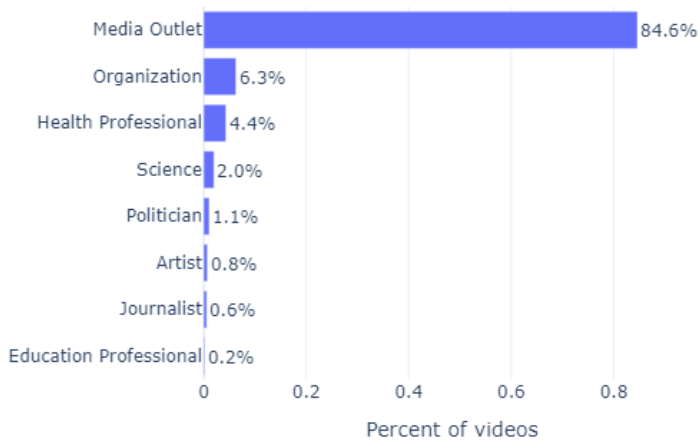
not possible to establish a direct correlation, the data suggest that this heightened political attention may have contributed to the rise in YouTube publications related to vaccines, which peaked in June 2021 with 1.389 videos.

Figure 3 shows the actors discussed vaccines in their YouTube videos. Note that media outlets predominate in the corpus collected for this study. More than 84% of the channels comprise media organizations, which generally use the platform to share their reports, originally produced for television. The distribution of videos in the other profiles is more balanced. Organizations – a category that includes public agencies from the Executive, Legislative, and Judiciary branches, and research institutions – make up 6.3% of the channels. Health professionals, science (which includes scientists, researchers, university professors, and science communicators) and politicians appear next, with 4.4%, 2%, and 1.1% respectively. The list is completed with the profiles of artists (0.8%), journalists (0.6%), and education professionals (0.2%).

**Figure 3**
*Percent of videos per profile*




With the qualitative analysis of the 25 topics initially generated by the machine learning algorithm, based on the video titles, we arrived at six general topics:

a) Vaccination campaigns: videos that address vaccina-

tion campaigns in general (flu, measles, polio, etc.), the beginning and progress of covid-19 vaccination, application of booster doses, and target publics (especially discussions about the covid-19 vaccine for pregnant women and adolescents).

b) Vaccines (production, commercialization, and distribution): a topic that brings together publications about the different stages that covid-19 vaccines produced by different laboratories (CoronaVac, AstraZeneca, Pfizer, Janssen) went through, from technical and scientific processes (safety and efficacy tests, mechanisms of action and immunological responses) to production, commercialization, and distribution agreements.

c) Politics: videos related to discussions in the political sphere that permeated the handling of the covid-19 pandemic in Brazil, and hence, vaccination, above all due to the controversial management of former president Jair Bolsonaro in his clash with other public authorities, for example with former governor of São Paulo, João Doria, opposition parliamentarians and representatives of the Judiciary branch.

d) Disinformation and denialism: videos that bring up the subject of vaccine-related denialism and disinformation, regardless of their stance on the issue. Since the topic modeling process does not distinguish between true and false claims, this topic encompasses content that discusses, analyzes, or presents narratives related to vaccine disinformation in general. It includes publications that seek to deny or clarify false information, such as the one stating that the covid-19 vaccine caused infection by HIV.

e) Adverse reactions or side effects: videos that address possible adverse reactions to the vaccine, especially with the disclosure of mild and serious cases. The topic includes publications explaining these effects, as well as others casting doubts on the vaccines. If a video discusses side effects in a manner that promotes fear or skepticism about vaccination, rather than offering an evidence-based explanation, it is categorized under this topic rather than under disinformation and denialism.

f) New vaccine (HIV and malaria): a specific topic that comprises informative videos on the development of new vaccines, such as vaccines against HIV and malaria.

The results indicate that most of the corpus (83%) consists of videos covering vaccination campaigns (see figure 4). Publications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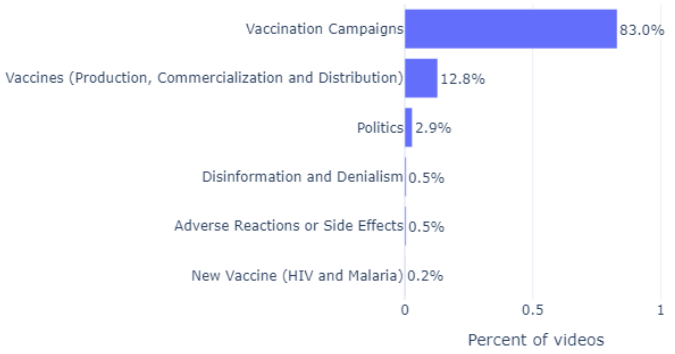
about the scientific and logistical aspects of the vaccine correspond to 12.8% while those on political aspects 2.9% of the total. Representing lower proportions of the total are the topics of disinformation and denialism (0.5%), adverse reactions or side effects (0.5%), and new vaccines (0.2%). While the topics of vaccination campaigns and vaccines present a sustained cycle of attention during the period, following the dynamics of the public health crisis, the other topics are characterized by peaks of publications in specific months (see figure A on supplementary material).

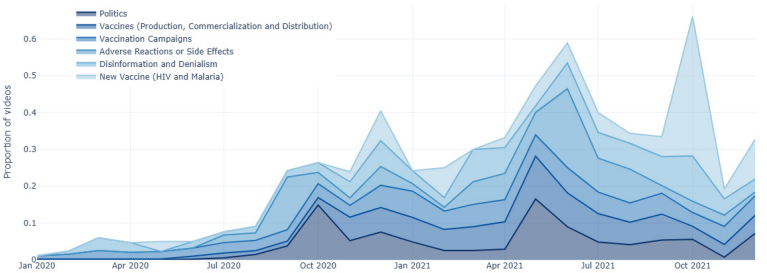
**Figure 4**




The topic distribution in figure 5 reveals distinct patterns in vaccine-related discourse over the first two years of the pandemic. The largest portion of discussions appears to be driven by the topics of politics and vaccines (production, commercialization, and distribution), indicating the central role of governmental decisions, logistical challenges, and policy debates in shaping public conversations. Vaccination campaigns also hold a significant share, particularly during peak periods, reflecting the rollout of immunization programs worldwide. Meanwhile, adverse reactions or side effects, as well as disinformation and denialism, contribute to the overall discussion but remain comparatively smaller in proportion, though their presence suggests persistent concerns and misinformation surrounding vaccine safety. Toward the later part of the timeline, there is a noticeable increase in discussions related to new vaccines, such as those for HIV and malaria, highlighting an expanding, although punctual, public interest beyond covid-19 vaccines.

**Figure 5**

*Percent of videos per topic (2020-2021)*




Finally, examining the distribution of videos by topic and profile revealed which subjects received the most or least attention from each actor. To facilitate viewing our findings, we excluded the topic of vaccination campaigns in figure 6, because it predominates in all the profiles (without it, the bars of the following topics are more visible). It is interesting to note that the four profiles in the upper portion, of a more institutional nature, follow a slightly more similar distribution than the others. The topic pertaining to the scientific and logistical aspects of the vaccine stands out in almost all the types of channels but is highest in the Science profile (18.7%), which also dedicates part of its videos to addressing the vaccine's side effects (6.5%). The topic of political aspects receives similar attention in the media outlets (3.2%) and political (3.3%) channels, although it predominates in channels of journalists (10.3%). On the other hand, health and education professionals focus their content on technical and scientific explanations about the vaccine, with 6.5% and 12.2% of videos, respectively, on this topic. Still, with respect to these two profiles, certain topics are absent, such as the political one. The channels of education professionals and artists are even less diverse in this regard. Possible explanations for this and the other findings described here are discussed in the next section.


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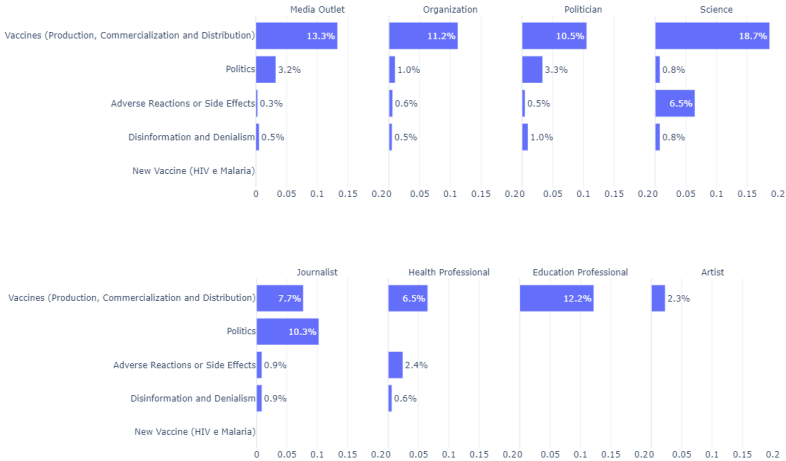
**Figure 6**

*Percent of videos per topic and profile*




## 5 Discussion

The analysis of 19.031 Portuguese-language YouTube videos on vaccines during the first two years of the covid-19 pandemic provides important findings on how the platform was used to disseminate information, participate in public discussions, and reflect the evolving socio-political landscape in Brazil. Our results indicate that the frequency of video publications followed key milestones of the pandemic, with notable peaks coinciding with major vaccination-related events. This aligns with previous studies that show the centrality of YouTube in the circulation of scientific information (Allgaier, 2020; Welbourne & Grant, 2016) and demonstrate how digital media engagement intensifies in response to significant public health developments (Cinelli et al., 2020).

The observed surge in video production between November 2020 and January 2021 corresponds with the global rollout of covid-19 vaccines, beginning with the first jab in the United Kingdom (Murray, 2020) and the subsequent start of vaccination in Brazil (Amâncio, 2021), after delays and shortages. The resurgence of video production in March 2021 aligns with growing political scrutiny in Brazil, particularly with the Parliamentary Inquiry Committee established in April 2021 to investigate vaccine procurement irregulari-

ties (Folha de S.Paulo, 2021). This suggests that political dynamics, predominantly centered around the then Brazilian president Jair Bolsonaro – whose rhetoric was openly antiscientific –, contributed to sustaining public interest and content creation regarding vaccines in Brazil (Bisol, 2020; Soares et al., 2023), with media outlets (3.2%) and political channels (3.3%) devoting attention to vaccine politics. Previous analyses have shown that vaccine discussions often become polarized, especially in politically charged environments (Bolsen & Palm, 2022). In Brazil, the role of the former President in opposing vaccination policies and engaging in public disputes with health authorities likely contributed to the politicization of vaccine narratives (Silva et al., 2022).

One finding that stands out is that this topic was proportionally more widely covered in videos by journalists (10.3%). In addition to being widely used by traditional media outlets as a way to make content available or to complement it beyond its original channels (TV, radio, print, and online news), YouTube provides individual journalists with a more personalized and opinion-based presence in the media sphere, discussing more specific topics such as, in this case, political issues.

Our results also show that media organizations were the predominant actors in vaccine-related content production, comprising over 84% of analyzed channels, indicating that traditional media outlets leverage digital platforms to extend their reach and maintain authority in public health discourse. These videos covered scientific processes, partnerships with international pharmaceutical companies, and logistical aspects of vaccine delivery. It is interesting to observe the predominance of these subjects in channels run by researchers, science communicators, and education professionals, and to a lesser extent, artists, who used the platform to address the technical and scientific issues surrounding the vaccine, benefiting from the interest generated by the pandemic (Almeida & Alves, 2020; Fackler & Sexton, 2020).

Public understanding of vaccines benefits from clear and accessible explanations of scientific concepts, yet such content often competes with more sensational or politically charged narratives (Dixon & Clarke, 2013). The fact that science channels dedicated a relatively higher proportion of their videos to vaccine production, commercialization, and distribution (18.7%) suggests that targeted efforts by scientists and educators could enhance the visibility of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evidence – based information. However, their lower representation raises concerns about the limited direct involvement of experts in the digital conversation – a gap that has been noted as a factor contributing to the spread of misinformation (Tangcharoensathien et al., 2020). The presence of institutional actors, such as governmental agencies and research institutions (6.3%), highlights the role of official communication in disseminating scientific information.

The long-awaited vaccination in Brazil, after months of the development of a safe and effective vaccine, might have contributed to the predominance of videos on vaccination campaigns (83%) and, to a smaller degree, scientific and logistical aspects of vaccine development, distribution, and efficacy (12.8%). This suggests that YouTube was used primarily as a platform for disseminating practical information about the vaccine rollout. This includes announcements of vaccination dates, target populations, and the availability of booster doses. In this regard, our findings are in line with those of studies that demonstrate that the covid-19 pandemic expanded approaches to vaccines, which had traditionally focused on the vaccination calendar (Neves & Massarani, 2022), to include information on efficacy and safety tests, different vaccine platforms and immunological effects (Basch et al., 2021; Marwah et al., 2021).

Although videos addressing disinformation and denialism accounted for only 0.5% of the total corpus, their presence underscores the continued challenge of vaccine skepticism. It is known that anti-vaccine narratives, even when quantitatively less prevalent, can exert a disproportionate influence on public perceptions and vaccine hesitancy (CCDH, 2021). It is important to note that the topic modeling approach used in this study does not distinguish between pro- and anti-vaccine content within this topic, meaning that both clarifications and endorsements of misinformation were captured. This reflects the complex nature of online discourse, where debunking efforts often coexist with misleading claims, sometimes inadvertently amplifying falsehoods (Larraz et al., 2024).

The presence of videos discussing adverse reactions or side effects (0.5%) indicates a persistent public concern regarding vaccine safety. Studies have shown that discussions about side effects can fuel vaccine hesitancy, particularly when framed without proper context or scientific explanation (Loomba et al., 2021). While some videos likely aimed to provide factual information, others may have contributed to fear and uncertainty. This finding underscores the

importance of strategic science communication to counteract misinformation while acknowledging legitimate concerns about vaccine safety (Betsch et al., 2018).

## 6 Conclusions

This study demonstrates that YouTube served as an important platform for vaccine-related information during the covid-19 pandemic in Brazil, primarily dominated by traditional media outlets and focused on practical vaccination information. While the platform showed potential for effective public health communication, the relatively low representation of health professionals and the concentration of political discourse in specific channel types suggest areas for improvement in future crisis communication strategies.

The methodological contribution of this study, particularly in applying NLP to analyze large-scale YouTube content, offers new possibilities for understanding online health communication patterns. Future research should focus on developing more sophisticated tools for analyzing video content and user engagement patterns to better understand the impact of different communication strategies.

For public health communicators and policymakers, these findings highlight the importance of developing targeted strategies for different platform actors and supporting health professionals in creating more engaging online content. Platform policies should focus on amplifying authoritative health information while maintaining clear distinctions between scientific and political discourse.

## NOTES

1 In the original Portuguese: vacina, vacinas, vacinado, vachina, vacinação, vacinal, v4c1n4, coronavac, pfizer, janssen e astrazeneca.

2 Available at: https://github.com/feusagittaire/ProfileNER-classifier

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