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## ABSTRACT

**Introduction:** The COVID-19 pandemic has had a number of impacts on people's daily lives around the world. The radical change in people's daily routines has led to an increase in the use and consumption of social media content. The scenario of uncertainty during this period has been favorable to the increase in bouts of anxiety and depression, leading many people to post content about these topics on social media. **Objective:** Develop a tool that uses natural language processing techniques to analyze Brazilian posts on X, formerly Twitter, during the pandemic. **Materials and Methods:** We collected and analyzed X posts related to mental health during the COVID-19 pandemic in Brazil. We used sentiment analysis and topic identification methods to evaluate the content of the posts. **Results:** The results showed that the pandemic has had a negative psychological impact on the lives of Brazilians. The "News" broadcast and the "Symptoms/Disorders" produced caused significant emotional discomfort, with women being the most affected. The analysis revealed an increase in the number of publications related to mental health during the pandemic. **Conclusion:** This study has identified new information that can help in the construction of public policies to minimize the negative effects of the pandemic on the mental health of the Brazilian population. The analysis of social media posts (X only) can provide valuable insights to better understand people's needs and concerns during public health crises such as the COVID-19 pandemic.

Keywords: Mental Health; Natural Language Processing; Social Networking.

## RESUMO

**Introdução:** A pandemia de COVID-19 trouxe diversos impactos na vida cotidiana das pessoas em todo o mundo. A mudança radical na rotina de vida das pessoas levou ao aumento do uso e consumo de conteúdo de redes sociais. O cenário de incerteza durante este período foi favorável para o aumento das crises de ansiedade e depressão, levando muitas pessoas a postarem conteúdo sobre esses tópicos em redes sociais. **Objetivo:** Desenvolver uma ferramenta que utiliza técnicas de processamento de linguagem natural para análise das publicações brasileiras no X, antigo *Twitter*, no período da pandemia. **Material e Métodos:** Foram coletadas e analisadas publicações do X relacionadas à saúde mental durante a pandemia de COVID-19 no Brasil. Utilizamos métodos de análise de sentimentos e identificação de tópicos para avaliar o conteúdo das postagens. **Resultados:** Evidenciaram que a pandemia trouxe impactos psicológicos negativos para a vida dos brasileiros. As "notícias" veiculadas e os "sintomas/distúrbios" produzidos, causaram desconforto emocional significativo, com as mulheres sendo as mais afetadas. A análise revelou um aumento no número de publicações relacionadas à saúde mental durante o período da pandemia. **Conclusão:** Este estudo identificou novas informações que podem ajudar na construção de políticas públicas para minimizar os efeitos negativos da pandemia na saúde mental da população brasileira. A análise das publicações nas redes sociais (apenas X) pode fornecer *insights* valiosos para entender melhor as necessidades e preocupações das pessoas durante crises de saúde pública como a pandemia de COVID-19.

Palavras-chave: Saúde Mental; Processamento de Linguagem Natural; Rede Social.

## INTRODUCTION

The internet has undeniably revolutionized human life, and its role became even more pivotal during the COVID-19 pandemic, enabling remote execution of various tasks across many industries. As most people confined themselves to their homes, they created a new routine. Initially, the ability to perform nearly all activities from home appeared appealing; however, this new routine elevated people's mental wear as the weeks passed. In their review paper, Brooks et al<sup>1</sup> found that factors such as the duration of quarantine, fear of infection, frustration and annoyance, and inadequate information about the disease and its care caused adverse psychological effects.

During lockdown, social networks become a refuge for many people seeking an outlet to express their feelings. These virtual spaces played a crucial role in transforming how we communicate and disseminate information. With a wide range of resources, social networks facilitated various user interactions, including text and audio messages, posts, polls, videos, photos, and news, among other features.

The number of new users joining social networks has been growing yearly. According to the report Digital 2022: Global Overview Statshot, published in partnership between We Are Social and Hootsuite, 4.62 billion people are registered on social networks, representing 58.4% of the world's population.<sup>2</sup>

Social network usage has also been growing in Brazil. Reports indicated that the number of internet users on social networks in the country increased significantly from 140 million in January 2020 to 171.5 million in February 2022,<sup>2,3</sup> reflecting a substantial rise in the number of Brazilians utilizing this means of communication.

With the pandemic, the topic of mental health has gained significant attention from researchers and health professionals worldwide. A study published two months after the pandemic began in China revealed that the rapid transmission of COVID-19 posed a severe challenge to Chinese mental health services.<sup>4</sup> In another paper,<sup>5</sup> the authors assessed the impact of news of the COVID-19 pandemic in China three days after its announcement by health authorities. Among the 1210 respondents, 53.8% rated the psychological impact of the outbreak as moderate or severe; 16.5% reported moderate to severe depressive symptoms; 28.8% reported moderate to severe anxiety symptoms, and 8.1% reported moderate to severe stress levels.

A study conducted in Brazil during the pandemic analyzed the frequency of sadness, nervousness, and sleep alterations experienced by adults and the elderly.<sup>6</sup> Response to a web-applied questionnaire revealed that 40.4% of the 45,161 Brazilian respondents frequently felt sad or depressed, while 52.6% often felt anxious

or nervous. Additionally, 43.5% reported the onset of sleep problems, and 48.0% experienced an aggravation of pre-existing sleep issues. Young adults, women, and people with a history of depression more frequently experienced feelings of sadness, nervousness, and sleep disturbances.

Other articles have highlighted various problems that could arise from the pandemic, such as increased alcohol and other drug use,<sup>7</sup> sleep disorders,<sup>8</sup> greater engagement with online gaming,<sup>9</sup> and increased suicide rates.<sup>10</sup> Some studies have also explored the relationship between social media and mental health. For instance, in one study,<sup>5</sup> the authors found that high exposure to social media was positively associated with anxiety and the combination of anxiety and depression. Chinese healthcare professionals and other individuals reported similar findings.<sup>4</sup>

According to the World Health Organization (WHO),<sup>11</sup> Brazil ranked as the most anxious country in the world in 2017, with approximately 18.6 million Brazilians living with this mental disorder characterized by excessive worry or apprehensive expectation that is persistent and difficult to control. Additionally, the report states that more than 300 million people worldwide live with depression, including 11.5 million in Brazil.

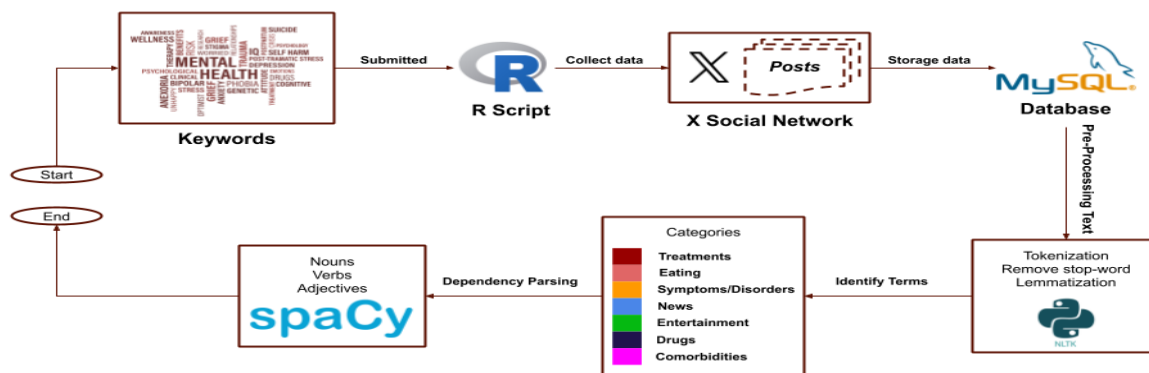
Given the high number of people who have been in isolation and the extensive use of social media, the research problem this study addresses is to understand how Brazilian social media users have expressed their experiences of anxiety and depression during the COVID-19 pandemic.

To answer this research question, this study aims to analyze the content of posts in Brazil from users reporting anxiety and depression between March 25, 2020, and November 20, 2021 (Mark 60% of the Brazilian population that completed the initial COVID-19 vaccination protocol - first and second dose). By examining data from periods when significant events occurred in the country, we seek to uncover novel information that can provide essential insights for developing public policies to mitigate the adverse effects the pandemic and quarantine period have had on the lives of Brazilians. The methodology will involve collecting and categorizing posts using sentiment analysis tools to identify trends, emotional triggers, and coping mechanisms shared by users. This approach will enable a comprehensive understanding of the psychological impact of the pandemic on the Brazilian population as reflected in social media discourse.

## MATERIAL AND METHODS

Several steps were required to carry out this work, detailed in the flowchart shown in Figure 1.

For this study, we initially created a list of 251 keywords to collect data from X. Psychologists recommended this list of activities to maintain good



**Figure 1:** Schematic flowchart of the methodological process. Initially, we developed specific keywords for data collection. Using these keywords, we employed a collection script to gather and store the data in a structured and efficient database. After storing the publications, we began pre-processing the data, including tokenization, removing stop words, and lemmatization. We then identified the main terms and categorized them into relevant areas of interest. Subsequently, we carried out a dependency analysis to identify the main actions of X users who published on topics related to mental health in Brazil.

mental health<sup>13</sup> during periods of isolation. Additionally, it included words related to the medical conditions of individuals experiencing anxiety and depression. These keywords were selected to ensure a comprehensive capture of the relevant conversations, providing a broad understanding of how individuals were coping with mental health issues during the pandemic.

We developed a script using the R programming language that utilizes Twitter’s rtweet API to authenticate users on the X platform and collect tweets.<sup>14,15</sup> We designed this script to automate data collection, enabling us to gather large volumes of tweets efficiently and systematically. By leveraging the capabilities of the rtweet API, we could access historical tweet data, ensuring our dataset was extensive and up-to-date.

To store the gathered data, we implemented a relational database following the structure suggested by Nogueira<sup>16</sup>, adapting it from the context of artisanal cheese in Brazil to mental health. This database structure allowed us to organize the tweets to facilitate efficient querying and analysis. After making the necessary adjustments, we stored all collected tweets for subsequent stages, ensuring that our data storage solution was robust and scalable to handle the large volume of data.

We applied natural language processing (NLP) techniques to extract relevant information from the data. First, we standardized and removed inconsistencies from all collected posts through a preprocessing step. We cleaned the text data using Python and the Natural Language Toolkit (NLTK) library by removing stop words,<sup>18</sup> emojis, and website links; this ensured that the text data was in a consistent format suitable for further analysis.

To analyze the context of the publications, we built a list with terms in Brazilian Portuguese categorized into Eating, Comorbidities, Drugs, Entertainment, News, Treatments, and Symptoms/Disorders. This list was created based on the word cloud analysis to quantify and understand the issues that most affected the mental health of Brazilians. Word cloud analysis provided a visual representation of the most frequently mentioned terms, helping us identify the predominant themes in the data.

We implemented a syntactic dependency analysis using the spaCy library to identify the features X users most frequently mentioned regarding their mental states during the pandemic.<sup>19</sup> This analysis aims to represent the syntactic structure of a sentence by identifying the role each word plays in the text and its relationship with other words. By examining the syntactic dependencies, we could gain insights into how users expressed their thoughts and feelings, revealing patterns in their language use.

To evaluate the issues that most affected Brazilians’ emotional condition, we specifically analyzed all classes of words, focusing on “verbs,” “nouns,” and “adjectives” as the most representative. Verbs provided insights into actions and behaviors, nouns indicated the subjects and objects of discourse, and adjectives described the qualities and attributes associated with mental states. This detailed linguistic analysis allowed us to uncover users’ underlying sentiments and concerns, contributing to a deeper understanding of the mental health challenges faced during the pandemic.

## RESULTS AND DISCUSSION

## Data collection and initial trends

During the research period, 14,088,316 tweets were collected and stored. The first four months (April, May, June, and July 2020) saw the highest number of posts, representing 37.8% of the tweets about anxiety and depression. With many people confined to their homes due to social isolation, posting content on social networks become part of Brazilians’ new routine. Figure 2 illustrates the variation in the number of publications over the months.

Overall, the number of posts decreased as the months progressed. From April 2020 to February 2021, this reduction in the number of publications amounted to approximately 71.9%. The transition to virtual activities, such as remote work, and the gradual resumption of in-person activities, such as school classes, caused this decrease.

In March 2021, the number of publications increased. During this month, Brazil faced a severe escalation in the COVID-19 crisis, with more than 2,000 daily deaths on the 10th. The state of São Paulo registered the first death due to a lack of hospital beds on the 18th. On the 23rd and 24th, Brazil surpassed the threshold of over 3,000 daily deaths and exceeded 300,000 total deaths from the disease.<sup>20</sup>

## Key phases and public sentiment

We identified four pivotal moments to understand better what Brazilians posted the most on X. The first phase, characterized by the onset of the pandemic, witnessed widespread apprehension regarding the disease and a surge in infection and mortality rates. During this time, messages promoting

masks and hand sanitizers gained significant traction among users.

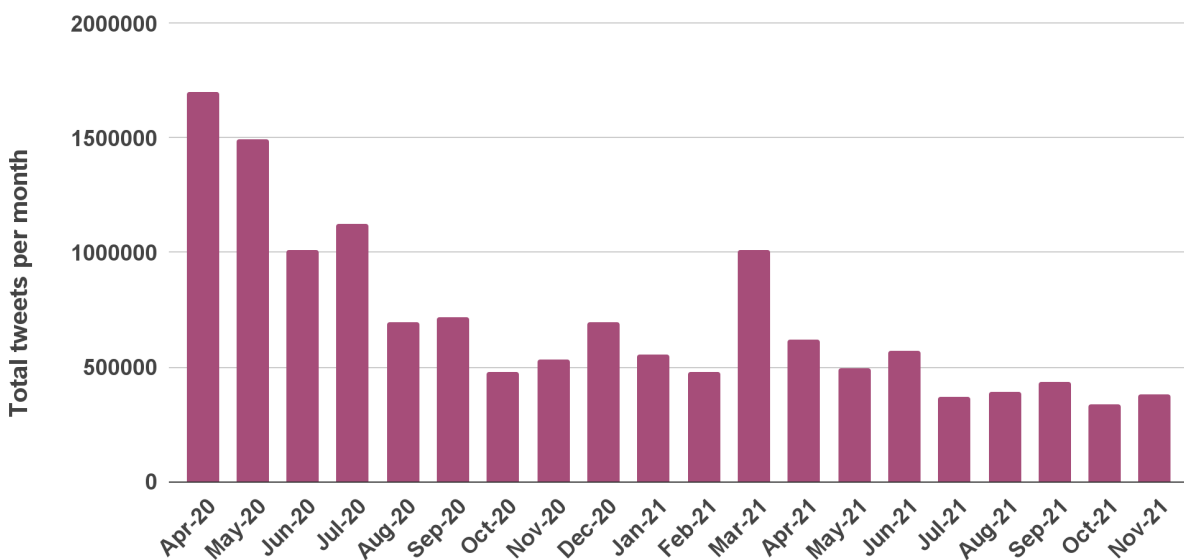
The second phase involved the implementation of stringent lockdown measures across multiple Brazilian states in May 2020. These measures, enacted by authorities and supported by the community, aimed to curb the escalating numbers of new COVID-19 cases and fatalities. This collective effort sought to flatten the infection curve and alleviate pressure on the pressure healthcare system, reflecting the community’s proactive response to the crisis.

The third moment pertains to the beginning of 2021. During this period, two significant events occurred: (i) the launch of COVID-19 vaccinations and (ii) the onset of the “oxygen crisis” in the state of Amazonas. This crisis led to a collapse of the public health system due to a surge in COVID-19 cases, resulting in a shortage of oxygen in hospitals. According to investigations by the Public Ministry of the State of Amazonas, this situation caused the deaths of 7 people and left 52 patients hospitalized with COVID-19 in the city of Manacapuru.

Finally, the fourth and last period chosen to examine the issues that most affected the mental health of Brazilians was November 2021. This month, Brazil reached the milestone of 60% of the population completing the initial vaccination protocol (first and second doses). Figure 3 illustrates the word cloud for each period discussed in detail.

## Analysis of public sentiment and key terms

In period (I), the words “quarantine,” “pandemia,” “ansiedade,” and “coronavirus” are prominently mentioned in Brazilians’ tweets. The high



**Figure 2:** Time series of the number of tweets about mental health collected over the months in Brazil.



**Figure 3:** Word cloud of four distinct moments of the pandemic. (I) April 2020 – the first month of the pandemic; (II) May 2020 – lockdown decree in Brazilian states; (III) January 2021 – beginning of COVID-19 vaccination in Brazil and the oxygen crisis in Manaus; (IV) November 2021 – 60% of the Brazilian population with the initial vaccination protocol (first and second dose) completed.

volume of posts during this time highlights the profound impact the early stages of the pandemic had on the mental health of Brazilians. The disruption of daily routines and the uncertainty of the situation created an environment of chaos, contributing to increased anxiety and depression. With the implementation of the lockdown in period (II), the focus on the same keywords from (I) becomes even more pronounced. Additionally, the words “casos” (cases) and “mortes” (deaths) gain greater prominence due to the rising incidence of the disease in the country.

In period (III), nearly a year into the pandemic, all the keywords highlighted in the previous word clouds appear again. However, two words that particularly stand out are “vacina” (vaccine) and “desemprego” (unemployment). The emergence of the term “vacina” is explained by the commencement of Brazil’s COVID-19 vaccination campaign on January 17, 2021, which brought hope for better days and a potential end to the pandemic.<sup>21</sup> The prominence of “desemprego” can be attributed to data from the Continuous National Sample Survey of Households conducted by the Brazilian Institute of Geography and Statistics,<sup>22</sup> which revealed that in the first quarter of 2021, Brazil’s unemployment rate reached 14.9%. Women were disproportionately affected, with an unemployment rate of 18.5%, 6.3% higher than that of men.

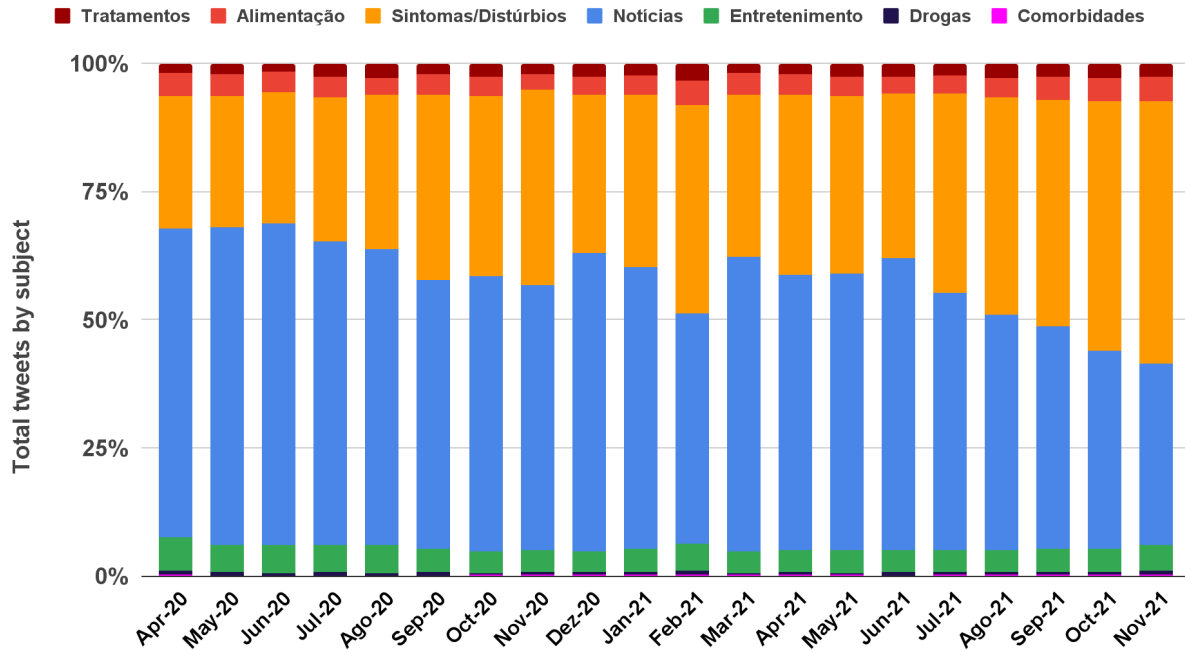
In period (IV), terms that had been prominent in earlier moments lost their significance, giving more words visibility to the terms “ansiedade” (anxiety), “depressão” (depression), “pânico” (panic), “stressed,” “crises,” and “angústia” (anguish). This shift in

terminology reflects the increasing emotional distress caused by the pandemic. The prominence of these words highlights the deep emotional challenges and mental health struggles faced by individuals during this time. To identify the most frequent topics and activities during the pandemic, we selected 54.1% of the tweets with at least one verb (including auxiliary verbs) for further examination.

Upon analyzing the categorized words in the subjects of interest, the category with the highest number of tweets was “Notícias” (310,399 posts), followed by “Sintomas/Distúrbios” (180,292 posts), “Entretenimento” (27,478 posts), “Alimentação» (22,293 posts), «Tratamentos» (12,916 posts), «Drogas» (3,183 posts), and «Comorbidades» (1,060 posts). Figure 4 provides a detailed representation of each category throughout the analysis period.

Over the months, “Notícias” and “Sintomas/ Distúrbios” emerged as the categories with the most mentions. For “Notícias,” the top ten Portuguese terms were: covid (87,820), quarentena (71,712), pandemia (65,745), mortes (17,593), casos (15,578), desespero (11,651), coronavírus (10,878), vírus (7,678), vacina (5,866) and desempregado (4,560). In the “Sintomas/ Distúrbios” category, the most frequently mentioned words were: tristeza (26,424), frescura (22,187), sono (16,941), estresse (13,973), medo (13,300), gatilho (9,355), pânico (8,117), sintomas (7,690), dor (7,129) e preocupado (6,990).

In the “Entretenimento” category, the most prominent terms were: jogo (4,416), festa (4,276), filme (2,340), Netflix (1,491), live (1,474), futebol



**Figure 4:** Quantitative evolution of the issues that most affected the mental health of Brazilians during the pandemic by COVID-19 in the period from April 2020 to November 2021.

(693), anime (405), cinema (379), YouTube (361). For “Alimentação,” the most mentioned terms included: pizza (1,351), pipoca (570), doce (459), refresco (456), suco (431), coxinha (410), churrasco (382), ovo (341), bala (260) and vitamina (253).

In the “Tratamentos” category, the most frequently mentioned terms were: médico (6,236), psicólogo (1,686), especialista (1,438), psiquiatra (1,395), remédios (1,072), meditação (656), respiração (143), ansiolítico (126), yoga (74) and psicoterapia (58).

For the “Drogas” category (both legal and illegal), the most mentioned terms included: cerveja (1,898), maconha (691), vinho (226), cigarro (198), coquetel (44), vodka (39), caipirinha (23), crack (23), whisky (11), chopp (8). In this context, any alcoholic beverage was considered a drug, including conventional cigarettes. Finally, in the “Comorbidades” category, the most frequent words were: anemia (500), diabetes (215), AVC (195), obesidade (88), cirrose (61).

Upon analyzing the data, we observed a predominant presence of “Notícias” (news) and “Sintomas/Distúrbios” (symptoms/disturbances) in the tweets during this period. These findings are consistent with observations from mental health literature, which documented a significant increase in psychological issues in 2020. A multicenter study across 11 countries reported a prevalence of over 48% and an incidence of 17.6% for post-traumatic stress symptoms, anxiety, depression, and panic disorder.<sup>23</sup>

Furthermore, we observed that “Sintomas/

Distúrbios” (symptoms/disorders) were mentioned more frequently over time, peaking in November 2021. The surge likely corresponds with rising daily COVID-19 infection and mortality rates, which may have intensified negative emotions due to the widespread vulnerability experienced before vaccines were developed. The increased focus on mental health discussions on X suggests that the pandemic’s challenging conditions exacerbated symptoms such as sadness, sleep disturbances, and triggers for anxiety attacks and depression. These issues are often dismissed or misunderstood by those unfamiliar with these disorders.

Without a well-defined routine, the study by Malta et al<sup>24</sup> observed that among 45,161 Brazilian respondents aged 18 and older, there was a deterioration in lifestyle. This included reduced physical activity, increased screen time, and higher consumption of ultra-processed foods, cigarettes, and alcoholic beverages.

Another notable observation from Figure 3 is that from April 2020 to June 2021, the “Notícias” category consistently had more prominence than the “Sintomas/Distúrbios” category. However, as of July 2021, the “Sintomas/Distúrbios” category began to gain more prominence. The increasing impact of the pandemic on people’s mental health caused this shift.

### Gender differences in mental health impact

We selected several adjectives frequently mentioned in the word clouds to determine which gender (female or male) experienced more significant effects of



anxiety and depression during the pandemic. Table 1 presents the results obtained from this analysis.

**Table 1:** Number of mentions of adjectives by gender; terms in the Brazilian Portuguese language.

Female	Male
<i>cansada</i> 10.009	<i>preocupado</i> 6.990
<i>ansiosa</i> 6.977	<i>ansioso</i> 5.364
<i>preocupada</i> 5.925	<i>desempregado</i> 4.560
<i>nervosa</i> 2.674	<i>cansado</i> 4.471
<i>estressada</i> 1.823	<i>nervoso</i> 1.263
<i>desempregada</i> 1.492	<i>estressado</i> 693
<i>deprimida</i> 973	<i>deprimido</i> 683
<i>angustiada</i> 504	<i>bravo</i> 208
<i>irritada</i> 460	<i>angustiado</i> 181
<i>brava</i> 408	<i>irritado</i> 180
<i>chorona</i> 265	<i>chorão</i> 72

The results indicate that, in general, women were more affected than men. Social isolation led to increased tasks for women, resulting in more frequent reports of fatigue on social media compared to men. Women also exhibited higher levels of anxiety, nervousness, stress, and depression, which aligns with findings presented by Barros et al<sup>6</sup>.

The survey data revealed that men showed greater concern, possibly influenced by unemployment. These were the only terms where the analysis more prominently expressed the male gender.

## CONCLUSION

After evaluating Brazilians' posts on X regarding the mental health landscape in Brazil, it is clear that the pandemic had significant negative psychological impacts. Each moment analyzed in the word clouds revealed highly expressed terms and related them to events in people's daily lives that prompted them to report on social networks.

Analyzing the results regarding the most impactful subjects, we found that "Notícias" and "Sintomas/Distúrbios" had the highest number of tweets. This indicates that these topics have become increasingly prevalent over time, highlighting how the pandemic has affected the mental health of X users.

When analyzing the occurrence of adjectives segmented by gender, we found that women were more affected, experiencing higher levels of fatigue, anxiety, nervousness, and stress compared to men. Conversely, men showed more significant worry, possibly due to unemployment, the second most mentioned term.

This initial study evaluates mental health content and the general context of publications collected from Twitter in Brazil. Future work will focus on developing

a sentiment analysis model to identify the polarity of sentiment and the emotions expressed in each post, enabling the quantification of sentimental and emotional aspects throughout the pandemic.

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