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Impact of Fake News about Vaccination on Mortality from COVID-19: An Epidemiological Analysis in Brazil

Impacto das Fake News sobre vacinação na mortalidade por COVID-19: uma análise epidemiológica no Brasil

Impacto de las noticias falsas sobre la vacunación en la mortalidad por COVID-19: Un análisis epidemiológico en Brasil

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Abstract

Objective: To correlate the temporal pattern of rates on mortality, vaccination coverage, and dissemination of fake news about COVID-19 in Brazil. **Methods**: Epidemiological study of aggregated data on COVID-19 from the Brazilian Ministry of Health and the Lupa and Aos Fatos fact-checking agencies from January 2021 to December 2022. We performed simple and multiple linear regressions to assess temporal trends and implemented Spearman's correlation for associations between variables. We established significance at $p<0.05$, with a 95% confidence interval (95% CI). **Results**: Fake news about vaccines correlated positively with mortality from COVID-19 ($\rho=0.473$; $p=0.020$; 95% CI: 0.102; 0.707). Fatality significantly decreased ($R^2=0.5733$; $p<0.001$; 95% CI: -2.396; -1.255). Vaccination coverage did not significantly correlate with mortality ($\rho=0.075$; $p=0.729$; 95% CI: -0.173; 0.308). We observed that the dissemination of fake news decreased over time ($R^2=0.0038$; $p=0.004$; 95% CI: -0.125; -0.034). **Conclusion**: The findings suggest that disseminating misinformation may have influenced mortality from COVID-19 in Brazil, reinforcing the need for effective strategies to combat the infodemic and promote vaccine confidence.

Descriptors: Communication; Disinformation; Vaccination; Epidemiology; Coronavirus Infections.

Whats is already known on this?
The literature addresses the relationship between fake news and vaccination in Brazil, highlighting how misinformation contributes to vaccine hesitancy, harms adherence, and compromises positive public health results.

What this study adds?
Using a methodological approach, this innovative study analyzes the epidemiological correlation between fake news, vaccination, and mortality from COVID-19 in Brazil, highlighting critical implications and public health strategies.

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Resumo

Objectivo: *Correlacionar o padrão temporal das taxas de mortalidade, de cobertura vacinal e de disseminação de fake news sobre COVID-19 no Brasil.* ***Método:*** *Estudo epidemiológico de dados agregados sobre COVID-19 do Ministério da Saúde do Brasil e das agências de checagem Lupa e Aos Fatos, de janeiro de 2021 e dezembro de 2022. Foram realizadas regressões lineares simples e múltiplas para avaliar tendências temporais e a correlação de Spearman para associações entre variáveis. Estabelecemos a significância em p<0,05, com intervalo de confiança de 95% (IC 95%).* ***Resultados:*** *Fake news sobre vacinas correlacionou-se positivamente com a mortalidade por COVID-19 (ρ=0,473; p=0,020; IC 95%: 0,102 - 0,707). A letalidade apresentou tendência decrescente significativa (R²=0,5733; p<0,001; IC 95%: -2,396 - -1,255). A cobertura vacinal não demonstrou correlação significativa com a mortalidade (ρ=0,075; p=0,729; IC 95%: -0,173 - 0,308). Observou-se que a disseminação de fake news diminuiu ao longo do tempo (R²=0,0038; p=0,004; IC 95%: -0,125 - -0,034).* ***Conclusão:*** *Os achados sugerem que a disseminação de desinformação pode ter influenciado a mortalidade por COVID-19 no Brasil, reforçando a necessidade de estratégias eficazes para combater a infodemia e promover a confiança nas vacinas.*

Descritores: *Comunicação; Desinformação; Vacinação; Epidemiologia; Infecções por Coronavírus.*

Resumén

Objetivo: *Correlacionar el patrón temporal de las tasas de mortalidad, la cobertura de vacunación y la diseminación de noticias falsas sobre la COVID-19 en Brasil.* ***Métodos:*** *Estudio epidemiológico de datos agregados sobre la COVID-19 del Ministerio de Salud de Brasil y las agencias de verificación de datos Lupa y Aos Fatos, de enero de 2021 a diciembre de 2022. Realizamos regresiones lineales simples y múltiples para evaluar las tendencias temporales e implementamos la correlación de Spearman para las asociaciones entre variables. Establecimos la significancia en p < 0,05, con un intervalo de confianza del 95% (IC del 95%).* ***Resultados:*** *Las noticias falsas sobre las vacunas se correlacionaron positivamente con la mortalidad por COVID-19 (ρ = 0,473; p = 0,020; IC del 95%: 0,102; 0,707). La letalidad mostró una tendencia decreciente significativa (R² = 0,5733; p < 0,001; IC del 95%: -2,396; -1,255). La cobertura de vacunación no mostró una correlación significativa con la mortalidad (ρ = 0,075; p = 0,729; IC del 95 %: -0,173; 0,308). Se observó que la diseminación de noticias falsas disminuyó con el tiempo (R² = 0,0038; p = 0,004; IC del 95 %: -0,125; -0,034).* ***Conclusión:*** *Los hallazgos sugieren que la difusión de información errónea podría haber influido en la mortalidad por COVID-19 en Brasil, lo que refuerza la necesidad de estrategias eficaces para combatir la infodemia y promover la confianza en las vacunas.*

Descriptores*: Comunicación; Desinformación; Vacunación; Epidemiología; Infecciones por Coronavírus.*

INTRODUCTION

The COVID-19 pandemic was recognized in Brazil as a Public Health Emergency from February 2020 to April 2022.[1] It has highlighted another critical global challenge: the infodemic. This event is characterized by an often inaccurate excess of information disseminated by unverified and unreliable sources, spreading rapidly[2] via the Internet or other media, often created to influence political views or as a joke.[3]

Recognizing the infodemic as a significant threat to public health, the World Health Organization (WHO) established, in 2020, the WHO Information Network for Epidemics (EPI-WIN) platform to combat misinformation.[4,5] Although communication noise and untruths have been a constant throughout the centuries, the Internet has exponentially accelerated the spread of fake news, hindering the thorough analysis of evidence and compromising the decision-making process.[6]

In the context of emerging diseases and the rapid spread of information through social media, fake news has found a favorable environment for its dissemination. In six Latin American countries, including Brazil, the population's limited ability to discern false information was observed, correlated with high mortality rates in regions where trusting social media information was higher.[6]

In Brazil, nine out of ten Brazilians have been exposed to at least one piece of false information about COVID-19, and seven out of ten believed at least one of these pieces of information.[7] Thus, fake news stands out as a significant obstacle in the fight against the coronavirus.[5] These data corroborate previous studies that indicate the role of fake news in reducing trust in science and health institutions and people's adherence to preventive measures, such as vaccination.[8,9]

The spread of fake news during the second year of the COVID-19 pandemic was as troubling as the disease.[10] The infodemic spread misinformation, influenced poor decision-making, and compromised public health. In addition to hampering adherence to preventive measures, such as wearing masks and social distancing, misinformation has directly affected vaccine acceptance, amplifying the pandemic's impact.

Given this outlook, conducting an epidemiological study that analyzes this problem and supports the formulation of effective policies to combat the infodemic is imperative. In this context, this study aims to correlate the temporal pattern of the rate of mortality, vaccination coverage, and the dissemination of

fake news about COVID-19 in Brazil, allowing a more in-depth assessment of the impact of misinformation on public health.

This research stands out as a pioneer at the national level in investigating this relationship in a detailed and systematic way, filling a significant gap in the existing literature. By integrating data on misinformation and epidemiological indicators, the study offers an innovative approach to understanding the consequences of the infodemic. In addition, the findings can support more effective strategies to mitigate the spread of fake news and strengthen the dissemination of accurate and verified information.

Thus, the central objective is to establish a correlation between mortality rates, vaccination coverage, and the dissemination of fake news. This will contribute to a deeper understanding of this dynamic and its implications for public health and support policies that reinforce trust in science and immunization.

METHODS

Epidemiological study of aggregated data, guided by the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) tool under the guidelines determined by Enhancing the Quality and Transparency of Health Research (EQUATOR) conducted in 2024, using the strategic data and information platform on COVID-19 developed by the Brazilian Ministry of Health[11] and vaccine data provided by the Ministry of Health[12] as a source. Fact-checking records from the agencies *Lupa* (https://lupa.uol.com.br/) and *Aos Fatos* (https://www.aosfatos.org/) were also used from January 2021 to December 2022, applying data referring to fake news related to vaccines against COVID-19.

Lupa is a hub for combating disinformation through fact-checking journalism and media education, whose website is hosted on the Piauí magazine portal in partnership with the UOL portal and *Folha de São Paulo*. The Aos Fatos agency is a journalistic organization investigating disinformation campaigns and fact-checking. Both agencies are verified members of the International Fact-Checking Network (IFCN), a global fact-checking network and a global leader in fact-checking excellence.

Data were collected by completing a new database based on the variables of interest. The outcome variable of this study was the monthly mortality from COVID-19 rate. It was calculated using the following formula:

$$Mortality = 100{,}000\ x\ \frac{Number\ of\ deaths\ from\ the\ COVID-19}{population}$$

The predictor variables of the study were vaccination coverage rate, fatality rate, and fake news vaccine rate. The fatality rate of the disease was calculated using the formula:

$$Lethality\ = 100x\ \frac{Number\ of\ deaths\ from\ the\ Disease}{Number\ of\ new\ confirmed\ cases}$$

In addition, vaccination coverage was also included with a data platform and strategic information on COVID-19 with the following formula:

$$Vaccine\ coverage\ rate\ = 100x\ \frac{Number\ of\ doses\ administered}{Total\ population}$$

Finally, the isolation rate was also included, based on data collected in fake news verification records, calculated using the following formula:

$$Fake\ News\ rate\ = 100x\ \frac{Number\ of\ Fake\ News\ about\ the\ vaccine}{Number\ of\ Fake\ News}$$

Trend lines were initially created for each indicator and the outcome over time for data analysis. The temporal pattern of these variables was analyzed using simple linear regression where the predictor was time (in months), and these were presented using graphs. Furthermore, we can identify the regression coefficient of determination (R^2), which varies from 0 to 1, where values closer to 1 identify a perfect trend. The line equation and p-value were defined to evaluate this pattern, where the former indicates an

increasing or decreasing trend, and the latter states whether it is significant ($p<0.05$). The trend was considered stationary when $p>0.05$.

The temporal pattern of these indicators was verified and then correlated with the outcome using Spearman's correlation test, as they did not have a normal distribution. Spearman's rho (ρ) varies between -1 and +1, where negative values indicate inversely proportional correlations and positive values indicate directly proportional correlations. Correlations with $p<0.05$ were considered significant.

In summary, to assess how these variables contribute to the mortality rate, the interpretation of these values is similar to that of correlations, except that the values of the β coefficients can vary from -∞ to +∞. Relationships with $p<0.05$ were also considered significant. The strength of these relationships was evidenced using the 95% Confidence Interval (95% CI).

The collected data were tabulated in Microsoft Office Excel® spreadsheets and then exported to the Statistical Package for the Social Sciences (IBM SPSS), version 23, to perform statistical analyses.

This study does not require prior submission to the Research Ethics Committee, since it is based exclusively on using secondary data in the public domain extracted from the Information Systems of the Unified Health System (SUS). Even so, the ethical precepts established by Resolutions N° 466/2012 and N° 510/2016 of the National Health Council were observed, preserving the subjects' anonymity by removing any identifying information, such as names or addresses, in the databases used.

RESULTS

Table 1 shows that the January 2021 to December 2022 period was marked by varying numbers of COVID-19 cases and deaths in Brazil and the doses of vaccines administered. In addition, we observed a troubling incidence of fake news about the vaccines, as detailed in the attached table. The registration of fake news started with 19 false news stories in January 2021, accumulating 159 by December 2022.

Brazil recorded a median of 378,000 confirmed cases, with 320,000 cases in the first quartile and 549,000 cases in the third quartile. The peak in cases was recorded in March 2022, with 933,452 cases. Deaths in Brazil followed a similar variation pattern, with a median of approximately 9.7 thousand deaths. The first quartile had approximately 4.4 thousand deaths and the third quartile had approximately 28.7 thousand deaths. April 2021 reported the highest number of deaths, with 78,942 records. The median of vaccines administered in Brazil was approximately 18.2 million doses, as shown in Table 1.

Table 1. Number of cases, deaths, vaccine doses administered, and fake news per COVID-19 vaccine. Fortaleza/CE, Brazil, 2024.

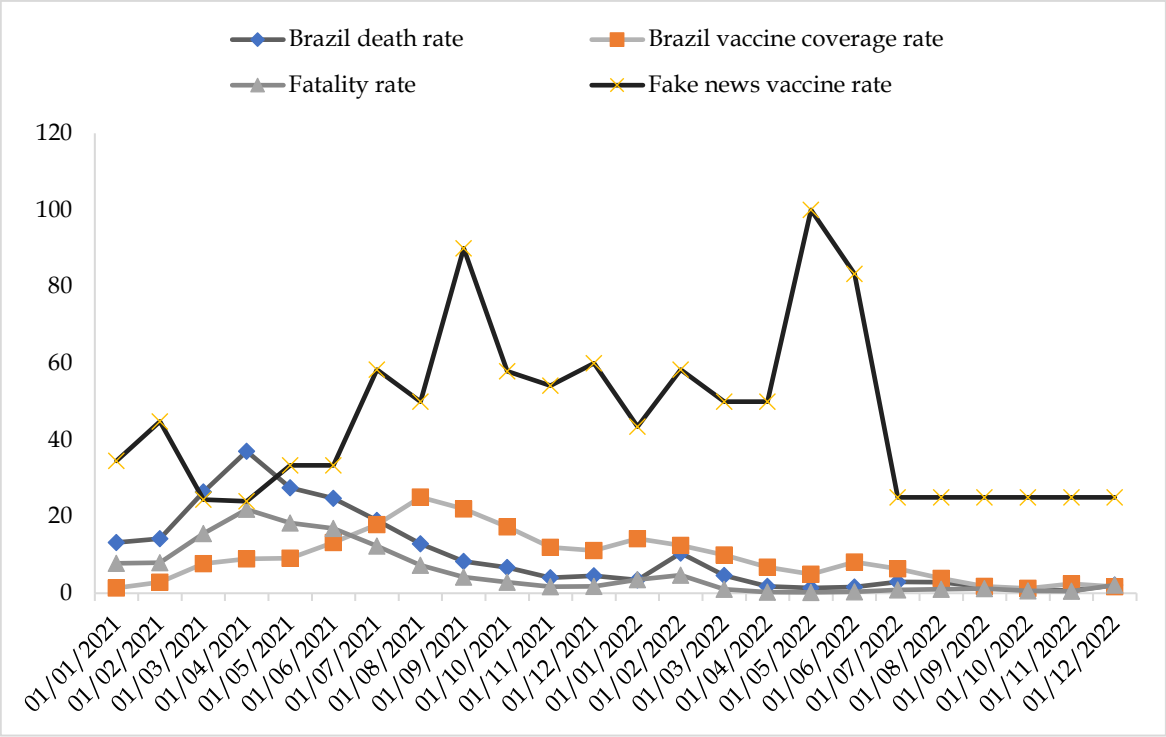
Day/Month/ Year	Cases	Deaths	Vaccine doses administered	Fake News Vaccines
01/01/2021	359593	28220	2859082	19
01/02/2021	379061	30276	6068211	13
01/03/2021	361195	56329	16379878	11
01/04/2021	360721	78942	19094758	11
01/05/2021	320820	58716	19486460	6
01/06/2021	311959	52692	28284458	9
01/07/2021	329394	40466	38207721	7
01/08/2021	378084	27522	53391624	3
01/09/2021	421604	17770	46860012	9
01/10/2021	500722	14271	36889923	11
01/11/2021	510901	8559	25591252	13
01/12/2021	539903	9644	23698951	9
01/01/2022	208018	7420	30260064	10
01/02/2022	476198	22389	26631947	14
01/03/2022	933452	9849	21191715	1
01/04/2022	1305447	3848	14416669	1
01/05/2022	1258651	2918	10570871	1
01/06/2022	952470	3482	17281910	5

01/07/2022	741844	6285	13593094	1
01/08/2022	576463	6105	8302965	1
01/09/2022	289002	3453	3837316	1
01/10/2022	317082	1989	2680221	1
01/11/2022	267132	1500	5317637	1
01/12/2022	214913	4560	3734097	1
Total	**12,314,629**	**497,205**	**474,630,836**	**159**

Source: The authors (2024).

The COVID-19 mortality rate in Brazil shows a significant decreasing trend (R^2=0.6176; p<0.001) (Table 2 and Figure 1), which indicates a statistically significant decrease in mortality over time. On the other hand, the Brazilian vaccination coverage rate shows a stationary trend (R^2=0.152; p=0.061), suggesting statistically significant invariance during the analyzed period.

Figure 1. Evolution of the rates on death, fatality, vaccination coverage, and fake news from COVID-19. Fortaleza/CE, Brazil, 2024.



Source: The authors (2024).

The fatality rate also shows a significant decreasing trend (R^2=0.5733; p<0.001), indicating a statistically significant decrease in the fatality rate over time. Finally, the fake news rate about vaccines shows a significant decreasing trend (R^2=0.0038; p=0.004), suggesting a statistically significant decrease in disseminating false information about vaccines over the analyzed period.

Table 2. Analysis of the trend of the rates on death, vaccination coverage, and fake news from COVID-19. Fortaleza/CE, Brazil, 2024.

Rates	Linear equation	R^{2*}	p-value	Trend
Brazil death rate	-0.0374x + 1,674.7	0.6176	<0.001	Decreasing
Brazil vaccine coverage rate	-0.012x + 543.21	0.152	0.061	Stationary
Fatality rate	-0.0231x + 1,032.6	0.5733	<0.001	Decreasing
Vaccine *Fake News* rate	-0.0063x + 326.26	0.0038	0.004	Decreasing

R^2= linear coefficient of determination

Source: The authors (2024).

Analyzing the studied indicators with COVID-19 mortality in Brazil identified a positive correlation between the fatality rate and the COVID-19 death rate (ρ=0.935; p<0.001) (Table 3). Moreover, a positive correlation was observed between the fake news rate about vaccines and the COVID-19 death rate (ρ=0.473; p=0.020). The correlation between the vaccination coverage rate in Brazil and the COVID-19 death rate was weak and not statistically significant (ρ=0.075; p=0.729).

Table 3. Correlation between the rates on mortality, vaccination coverage, and fake news from COVID-19. Fortaleza/CE, Brazil, 2024.

Variables	Spearman's Rho	p-value
Brazil vaccine coverage rate	0.075	0.729
Fatality rate	0.935	<0.001
Vaccine *Fake News* rate	0.473	0.020

Source: The authors (2024).

In summary, when inserting the variables into a multivariate linear regression model, we found that the case fatality rate remained strongly related to COVID-19 mortality (β=1.545; p<0.001), showing the direct influence of case fatality on COVID-19 mortality. Furthermore, the rate of fake news about vaccines also showed a significant relationship with COVID-19 mortality (β=0.035; p=0.038), indicating that disseminating false information can adversely affect health outcomes. While negatively related to mortality, the vaccination coverage rate was not statistically significant (β=-0.103; p=0.140) (Table 4).

Table 4. Multivariate regression of factors related to mortality, vaccination coverage, and fake news from COVID-19. Fortaleza/CE, Brazil, 2024.

Variables	β*	Standard Error	p-value	95% CI†
Brazil vaccine coverage rate	-0.103	0.067	0.140	-0.243 - 0.037
Fatality rate	1.545	0.050	<0.001	1.441 - 1.649
Vaccine *Fake News* rate	0.035	0.016	0.038	0.002 - 0.069
Constant	1.321	0.648	0.055	-0.030 - 2.671

*β = Multiple linear regression coefficients; † 95% CI = 95% Confidence Interval
Source: The authors (2024).

DISCUSSION

Scientific literature aimed to show how harmful fake news is, individually and collectively, in the Brazilian political and social outlook. This research is a relevant and unprecedented indication of the severe consequences triggered by the unbridled spread of fake news in health. In Brazil, during the first six months of the COVID-19 pandemic, the most frequent thematic categories of fake news were political, for example, government officials disseminating false information about vaccination against COVID-19 (20.1%), epidemiological and statistical aspects related to incidence and deaths (19.5%), and prevention measures (16.1%).[13]

In the first six months of the COVID-19 pandemic in Brazil, fake news circulated predominantly in three thematic areas: political content – including false statements by authorities regarding vaccination (20.1%) – epidemiological and statistical aspects related to the incidence and mortality of the disease (19.5%), and prevention measures (16.1%).

Fake news disseminated during the COVID-19 pandemic has generated confusion, panic, reduced vaccination coverage, and increased anxiety, with adverse repercussions for public health. The problem has escalated in contemporary society, so authors suggest media literacy education as an essential measure.[14] However, the proposed temporary solutions do not address its root, which lies in society's limited ability to discern truthful information from false information.

The importance of quality journalism is highlighted, as social networks have partially replaced the traditional function of filtering information. In this way, academia has devoted considerable efforts to understanding this event in scientific articles. Addressing this challenge requires a multifaceted approach involving the promotion of media literacy, strengthening responsible journalism, and continuously advancing academic knowledge on the subject.[15]

This research revealed a positive correlation between multiple events in the period analyzed, including indicators of deaths, doses of vaccines administered against COVID-19, and the dissemination

of fake news. Specifically, the correlation between the rate of dissemination of fake news about vaccines and the rate of deaths from COVID-19 stood out, which coincides with the beginning of vaccination campaigns in January 2021 in Brazil.

Between 2020 and 2021, one in five fake news stories circulated among Brazilians was about vaccines. This misinformation influenced risky behaviors, such as resistance to vaccination, although most people (72%) declared they intended to get vaccinated[8] in the first year of immunization.

Regarding the Brazilian population's risky behaviors and decisions based on fake news, a study points out that one of the reasons for this response was health politicization during the COVID-19 crisis. After all, many of these decisions were influenced by political choices based on emotions and passions, which is an additional challenge.[16] Emotional decisions to the detriment of rationality reflect a dynamic in which rational and scientific arguments have little impact in the face of deep-rooted political convictions.

This study used secondary data that revealed a significant evolution of the COVID-19 pandemic in Brazil over the analyzed period. The variation in confirmed cases and deaths showed considerable fluctuation, highlighting the peak of cases in March 2022 and April 2021, the period with the highest number of deaths. However, the median number of vaccines administered suggests the ongoing effort to mitigate the spread of the disease, indicating an active response by health authorities to contain the COVID-19 advance through immunization.

The results also indicate a significant downward trend in both the fatality rate and the dissemination of fake news about vaccines over the period studied. However, the positive correlation between the fatality rate and mortality from COVID-19 suggests that effective public health measures may have directly reduced the disease's fatality.

Furthermore, the positive association between the rate of fake news about vaccines and COVID-19 mortality highlights the importance of combating misinformation to improve outcomes. On the other hand, the weak and insignificant correlation between the vaccination coverage rate and COVID-19 mortality highlights the need to evaluate other factors that may influence vaccination outcomes.

Given the high number of deaths in Brazil during the period analyzed, the study corroborates the conclusion of Nieves-Cuervo *et al.*[6], when they stated that the country was among those with the highest incidence and mortality from COVID-19 worldwide. However, they consider it hard to assess the role of fake news and mortality from COVID-19 due to the lack of political and governmental actions, governance problems, and insufficient response to the pandemic crisis.

Given the mentioned above, combatting disinformation requires promoting quality and transparent information. To this end, it is vital to establish regulatory standards to address fake news.[17] This effort must involve both government agencies and society. Opening effective communication channels with citizens is essential to address their demands and concerns during critical times. Moreover, public bodies should invest in public communication to ensure that people can make informed decisions about their health based on robust scientific evidence.[16]

The corresponding values of multivariate linear regression examined the relationship between different variables and COVID-19 mortality. The analysis revealed that the case fatality rate was positively and significantly related with mortality, which highlights its direct role in determining COVID-19-related health outcomes.

Fake news about vaccines revealed a significant association with mortality. Although the vaccination coverage rate had a negative relationship with mortality, it was not statistically significant, indicating that other factors may influence vaccination results beyond mere coverage.

In some studies, the analysis of vaccination coverage against COVID-19 and its relationship with mortality reveals divergences. However, the effectiveness may vary depending on the context, with specific variants, such as virus type or geographical factors.[18] The divergences between studies highlight the relevance of considering multiple factors to assess vaccine effectiveness in reducing mortality.

However, other studies prove this negative relationship, pointing to the vaccine's effectiveness in reducing deaths from COVID-19, such as the Brazilian research that proved that the advance of vaccination reduced the number of deaths caused by the disease in the country by 96.4% from 2020 to 2021.[19]

Furthermore, a *Fiocruz* study concluded that vaccination can protect against contamination, hospitalization, and death from COVID-19, even in more socially vulnerable communities, where there is typically greater transmission.[20] These findings highlight the importance of comprehensive approaches to address the pandemic challenges, including health interventions and actions to combat misinformation and promote trust in vaccination.

While this study offers valuable insights into the relationship between the spread of fake news, vaccination coverage, and COVID-19 mortality in Brazil, some limitations should be considered. First, aggregated and secondary data may not capture all the local and individual nuances influencing mortality and vaccination uptake. However, using verified and reputable sources, such as the Brazilian Ministry of Health's platform and fact-checking agencies, minimizes this limitation.

The variable accuracy of fake news reporting may have also affected the reliability of the results. However, the inclusion of data from multiple fact-checking sources contributed to achieving robust analyses. Furthermore, the analysis is restricted to the January 2021-December 2022 period, which may not reflect recent or future changes in the pandemic's dynamics and the dissemination of information but provides a solid basis for understanding the impacts during a critical period of the pandemic.

The thorough statistical analysis applied in this study allows for relevant inferences, contributing to studies on the influence of fake news and vaccination coverage on mortality from COVID-19. However, the observed correlation does not necessarily imply causality.

CONCLUSION

This study found a significant correlation between the dissemination of fake news about vaccines and mortality from COVID-19 in Brazil, showing that misinformation adversely affected public health. Although the mortality rates and fake news showed a decreasing trend, they contributed to the high mortality rate during the period analyzed. Although vaccination coverage was relevant, it did not significantly correlate with mortality, suggesting that other factors may influence these results.

These findings underscore the importance of comprehensive strategies to combat misinformation and promote accurate and verified information. The relationship between fake news and mortality highlights the need for effective interventions to mitigate the infodemic by strengthening trust in vaccines and health authorities. Promoting media literacy and strengthening responsible journalism are essential to address the pandemic's challenges and improve future public health outcomes.

CONTRIBUITIONS

Contributed to the conception or design of the study/research: Cunha AR da, Garces TS, Moreira TMM. Contributed to data collection: Cunha AR da, Barakat RDM, Garces TS, Moreira TMM. Contributed to the analysis and/or interpretation of data: Cunha AR da, Barakat RDM, Garces TS, Moreira TMM. Contributed to article writing or critical review: Cunha AR da, Barakat RDM, Garces TS, Cestari VRF, Moreira TMM. Final approval of the version to be published: Cunha AR da, Barakat RDM, Garces TS, Cestari VRF, Ferreira SRM, Cavalcante NRP, Moreira TMM.

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