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# COVID-19 vaccination, incidence, and mortality rates among indigenous populations compared to the general population in Brazil: Describing trends over time

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## Summary

**Background** Chronic social and health inequities faced by indigenous peoples in Brazil foretell the detrimental impact of COVID-19.

**Methods** We use de-identified, publicly available data from the Ministry of Health from March/2020 - December/2021 to describe vaccination coverage, cumulative incidence, and cumulative mortality rates due to COVID-19 among indigenous peoples. We also compare vaccination coverage among indigenous peoples with that reported for older adults, who were simultaneously included as a priority group in the vaccination strategy. Finally, we compared COVID-19 incidence and mortality rates in the indigenous population with that reported for the general Brazilian population.

**Findings** We found important heterogeneities in vaccination coverage across the 34 indigenous districts, and a lower overall coverage among indigenous peoples compared to older adults. We observed higher COVID-19 cumulative incidence rates among indigenous populations compared to the general Brazilian population. Although mortality rates were seemingly lower, data should be interpreted with caution due to a younger age structure and more frequent underreporting of cases and deaths among indigenous populations. After the beginning of COVID-19 vaccination program, we observed a decrease in both incidence and mortality rates among indigenous peoples in all Brazilian regions.

**Interpretation** The COVID-19 pandemic has had a heavy toll on vulnerable populations. Although social and geographic isolation challenges the implementation of any vaccination program for indigenous populations, prior experience suggests that the COVID-19 vaccination strategy lacked effectiveness. The absence of a coordinated strategy to reinforce the importance of the vaccine and other prevention methods, to guarantee the access to trustworthy information, and to respond with the necessary resources in extreme situations, resulted in lower COVID-19 vaccination coverage, higher incidence rates, and preventable deaths due to COVID-19 among indigenous peoples in Brazil.

**Funding** This work was not supported by specific funding.

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**Keywords:** Indigenous populations; COVID-19; Vaccine; Incidence; Mortality; Trends over time; Health inequities

## Introduction

Brazil has a large and diverse population of indigenous peoples, comprising approximately 896,917 individuals divided into 305 ethnicities, and speaking nearly 274

different original languages.<sup>5</sup> Indigenous peoples in Brazil live in both urban and rural areas. Currently, there are 725 indigenous lands with an extension of 1,173,776 km<sup>2</sup>, representing 14% of the total extension of the country. However, the indigenous lands in Brazil are under different legal status regarding the recognition and protection process. Initially, the lands undergo an identification process; if approved, their limits have

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The Lancet Regional Health - Americas 2022;13: 100319

Published online 19 July 2022  
<https://doi.org/10.1016/j.lana.2022.100319>

### Research in context

#### *Evidence before this study*

Data from the pre-vaccination period suggest the demographic and clinical characteristics in indigenous peoples in Brazil that are associated with increased risk of death in COVID-19, including male sex, older age and the need of ventilatory support.<sup>1,2</sup> However, little is known about the COVID-19 vaccination coverage, cumulative incidence, and mortality rates among indigenous peoples over the post vaccination period. Furthermore, data from Kaiapó indigenous population shows that SARS-CoV2 infection spread rapidly in the population, highlighting the importance of indigenous health policies to minimize the impact of pandemic on these communities.<sup>3,4</sup>

#### *Added value of this study*

This is the first study to describe COVID-19 vaccination coverage, cumulative incidence and mortality rates among Brazilian indigenous peoples over time, and to compare these indicators with the general population and other priority groups in Brazil. We found that the health disparities faced by indigenous peoples were exacerbated during the COVID-19 pandemic, despite the prioritization in the vaccination strategy, with lower vaccination coverage compared to older adults, and higher incidence rates compared to the general population.

#### *Implications of all the available evidence*

Strategies to increase the effectiveness of existing policies and to improve communication regarding health issues are urgently needed to reduce health disparities among indigenous peoples.

to be acknowledged, and the effective homologation status occurs only after approval by federal-level legislation. Nowadays, 122 (10,840 km<sup>2</sup>) indigenous lands are in process of identification; 43 (21,793 km<sup>2</sup>) are identified; 74 (73,056 km<sup>2</sup>) are declared; and 487 (1,068,085 km<sup>2</sup>) are officially homologated lands, representing only 67% of all the indigenous lands according to 2021 data.<sup>6</sup> Nevertheless, even officially homologated indigenous lands are sometimes under the risk of invasion by non-indigenous groups, such as illegal miners and loggers, missionaries, and squatters.

Health indicators of indigenous peoples in Brazil highlight the state of vulnerability of these populations. Throughout the country, infant mortality was 60% higher among indigenous peoples when compared to the overall population.<sup>7</sup> Among indigenous peoples living in officially homologated lands, half of the population had up to 22 years of age, a demographic age distribution that suggests significantly higher birth rates and early mortality.<sup>5</sup> The quality of antenatal care

also depicts these health inequities, since only 34% of all indigenous pregnant women initiate antenatal care at early stages of pregnancy. They also face a high incidence of infectious diseases such as malaria, tuberculosis, sexually transmitted infections, and vaccine-preventable diseases, highlighting a gap in healthcare that could be reduced with effective interventions tailored to each indigenous population.<sup>8</sup> These data exemplify some of the long-term social and health inequities faced by indigenous peoples in Brazil, and foretell a greater impact of emerging public health issues such as the COVID-19 in this population.

Indigenous peoples are especially at risk in the pandemic scenario because of genetic susceptibilities, cultural aspects and economic activities in their territories. The introduction of new infectious agents among indigenous groups is alarming due to the potentially lower variability of immune response and other genetic susceptibilities, leading to increased disease severity and mortality.<sup>4</sup> In addition, cultural aspects such as the social organization in indigenous villages may challenge physical distancing measures and facilitate the spread of SARS-CoV-2.<sup>3</sup> Economic activities in indigenous lands, such as commercial agriculture, mining, and road constructions, increased under Bolsonaro's government in Brazil, exponentiating the likelihood of exposure of indigenous populations to the virus. As an example, in February 2021, the government revoked a prohibition of monoculture plantations in indigenous lands. In addition, the president himself declared he would not implement the demarcation of a single additional square centimetre of indigenous lands, threatening the territorial protection of indigenous lands awaiting demarcation.<sup>9–11</sup> Finally, it is important to point out that, in the case of indigenous populations, the pandemic scenario threatens the survival of entire cultures, since the death of a tribal chief or elder may result in the extinction of collective knowledge that is perpetuated orally from generation to generation.

Data concerning the outreach of vaccination strategies, incidence and mortality rates in this population are not easily available, and a detailed analysis could inform if the chronic social and health inequities faced by indigenous peoples persisted or were further exacerbated during the COVID-19 pandemic despite the prioritization in the vaccination strategy.

In this study, we briefly describe demographic, health and social characteristics of indigenous peoples in Brazil, and use publicly available data from the Brazilian Ministry of Health to compare vaccination, incidence and mortality rates among indigenous peoples and other priority groups of the general population in Brazil between March 2020 and December 2021.

### Methods

In this descriptive study, we present COVID-19 cumulative incidence and mortality rates and present the

vaccination coverage in Brazilian indigenous peoples aged 18 years old and older. We compare vaccination coverage in this population with that reported for older adults and compare COVID-19-specific incidence and mortality rates among indigenous peoples with numbers reported for the general population in Brazil. We extracted study data from publicly available sources from the Brazilian Ministry of Health.

We extracted data on the vaccination coverage of indigenous populations from official epidemiological reports. Although the vaccination of indigenous peoples began in January 2021, the first available surveillance report dates from March 2021. For comparison with the Brazilian general population, we opted for contrasting the progress of indigenous vaccination coverage with that reported for older adults, since this was another priority group starting vaccination in the same calendar period. This comparison includes information up to December 2021, corresponding to the end of the first year of the COVID-19 vaccination program in Brazil.

We also briefly describe the social, demographic, and healthcare context of indigenous peoples in Brazil using data from the Brazilian demographic census and Fundação Nacional do Índio (FUNAI) registries, as to facilitate the interpretation of COVID-19-related outcomes in these populations.

Estimates of COVID-19 vaccination coverage are presented as percentages of the total target population. Cumulative incidence and mortality rates are presented as events per 100,000 population for each study period. We present frequencies and percentages with no reference to precision intervals or statistical tests comparing the indigenous and general populations since our data depicts information from the complete population rather than a sample.

This study used publicly available, de-identified data. The institutional ethics committee reviewed and approved the study with exemption of informed consent. We received no specific funding or financial support for this study. We present study results in accordance with STROBE Statement.

## Results

The most recent Brazilian demographic census performed in 2010 reported 896,000 self-declared indigenous individuals living in the country, of whom 324,834 (36%) resided in urban areas and 572,083 (64%) lived in rural areas.<sup>12</sup> The last census also describes 305 different indigenous ethnicities in Brazil, speaking 274 distinct original languages. Among those living outside indigenous lands, the percentage of Indigenous peoples speaking traditional languages is 13%, contrasting with 57% among those living within their lands.<sup>5,8</sup> In addition to its importance in protecting the cultural heritage of their inhabitants, indigenous lands also comprise a large percentage of the remaining preserved areas of

the Brazilian Amazon Forest. Studies have shown that 20% of this unique biome has been deforested in the past 40 years, highlighting the importance of protecting indigenous lands as a means of safeguarding natural resources.<sup>13</sup>

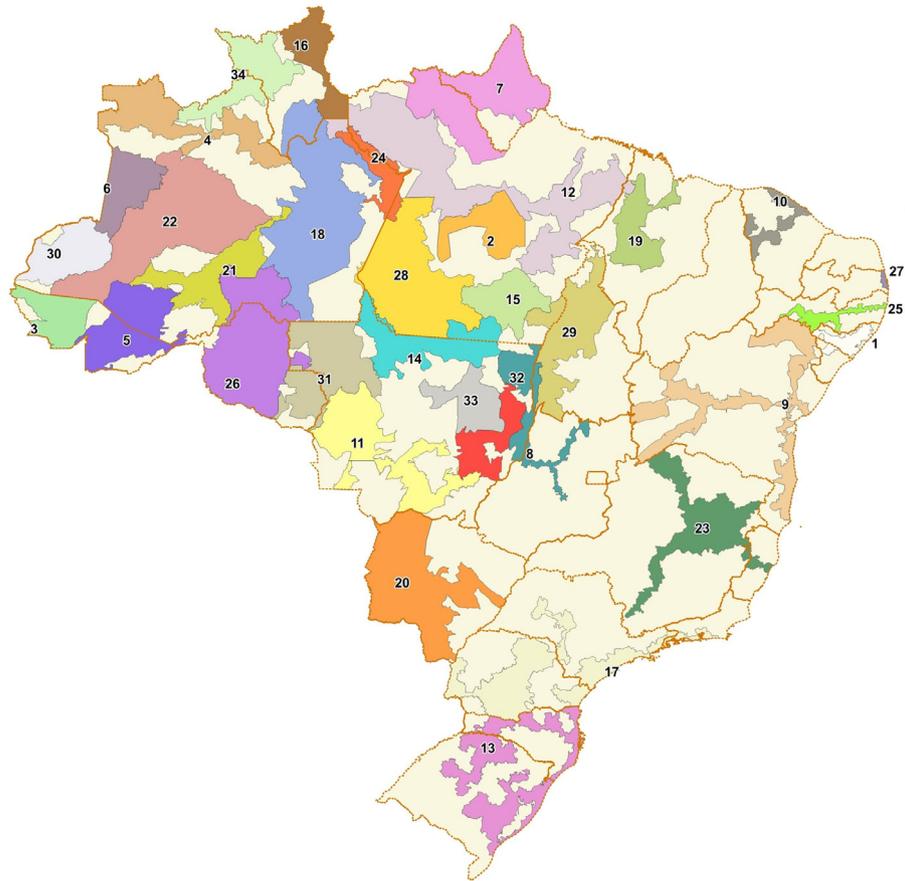
The Brazilian indigenous population has been decreasing since the Portuguese colonization in 1500, with the complete extinction of many indigenous groups. However, since the last decades of the 20<sup>th</sup> century, indigenous populations have been growing, although with lower rates in recent years. In the 1990's, the indigenous population grew 11% per year, whereas in the 2020's the population growth was only 1%.<sup>14</sup>

Indigenous peoples are distributed across all 26 Federal states in the country according to official data, and 81% of the Brazilian municipalities are home to at least one self-declared indigenous inhabitant. Most indigenous lands are located in the North region of the country (54%), in preserved areas in the Amazon Forest, followed by the Central-West, the Northeast, South, and lastly the Southeast region.<sup>15</sup>

The National Policy of Healthcare for Indigenous Peoples (PNASPI) was approved in 2002, aiming to improve primary health care for these groups. As part of this policy, 34 special units (Distritos Sanitários Especiais Indígenas, DSEIs) were strategically created, prioritizing the geographic distribution of indigenous groups rather than Federal States' limits (Figure 1; Supplement Table 1). In 2010, the Special Secretary of Health for Indigenous Populations (SESAI) was also created to support and improve the implementation of the PNASPI, and to enhance the coordination with other Secretaries and Policies of the Brazilian Unified Health System (SUS).

The DSEIs operate in accordance with a co-responsibility framework with SESAI, using a decentralized management and care model. The structure includes community-based health facilities and referent health units located in the indigenous lands, providing primary health care to local communities. The workforce relies on trained indigenous health agents and non-indigenous healthcare providers working both on site and with itinerant activities, visiting distant communities. In addition, the DSEIs work with housing units located in urban areas (Casa de Saúde Indígena – CASAI), where indigenous patients and family members can stay whenever more complex health procedures in secondary or tertiary-level care are necessary.<sup>8</sup> The overall healthcare structure is depicted in Figure 2.

The Brazilian COVID-19 vaccination program started in January 2021, including indigenous populations over 18 years among the priority groups. The overall indigenous vaccination coverage was 73% for dose 1 and 55% for dose 2 in March 2021, and increased to 90% for dose 1 and 85% for dose 2 by December 2021 (Figure 3).<sup>17,18</sup> We found important heterogeneities in the progress of vaccination coverage over time across



**Figure 1.** Geographic distribution of the 34 Brazilian Indigenous Health Districts (DSEIs) (translated from the Brazilian Ministry of Health)<sup>16</sup>

1. Alagoas e Sergipe; 2. Altamira; 3. Alto Rio Juruá; 4. Alto Rio Negro; 5. Alto Rio Purus; 6. Alto Rio Solimões; 7. Amapá e Norte do Pará; 8. Araguaia; 9. Bahia; 10. Ceará; 11. Cuiabá; 12. Guamá-Tocantins; 13. Interior Sul; 14. Kaiapó do Mato Grosso; 15. Kaiapó do Pará; 16. Leste de Roraima; 17. Litoral Sul; 18. Manaus; 19. Maranhão; 20. Mato Grosso do Sul; 21. Médio Rio Purus; 22. Médio Rio Solimões e Afluentes; 23. Minas Gerais e Espírito Santo; 24. Parintins; 25. Pernambuco; 26. Porto Velho; 27. Potiguara; 28. Rio Tapajós; 29. Tocantins; 30. Vale do Javari; 31. Vilhena; 32. Xavante; 33. Xingu; 34. Yanomami.

the DSEIs (Supplement Table 2). While some DSEIs had very high vaccination coverage by March 2021, some remained with vaccination coverage below 60% by December 2021.<sup>19,20</sup> This variability was highest in the DSEIs located in the North and Central-west regions, potentially reflecting challenges in vaccinating populations living in distant communities. However, some difficult-to-reach DSEIs reached high vaccination coverage, suggesting that other factors may have influenced these outcomes.

Figure 3 presents yearly cumulative incidence and mortality rates for COVID-19 reported in 2020 and 2021 for the indigenous populations in Brazil. We observe a dramatic reduction of COVID-19 cases and deaths in 2021 compared to 2020. These numbers, particularly the cumulative incidence estimates, are likely underestimated due to a scarcity of confirmatory tests for patients with mild disease presentation. However,

these findings point to a beneficial impact of the vaccination program for the indigenous populations in Brazil.<sup>18–25</sup>

We compared percentages of COVID-19 vaccination coverage among indigenous peoples in December 2021, with the vaccination coverage among older adults in the same calendar period. Since both populations received priority in the Brazilian vaccination strategy, similar vaccination coverage would be expected.<sup>26,27</sup> However, we observed that the indigenous populations achieved lower coverage when compared to most age categories of older adults in the general population, except those above 90 years old (Figure 4).

Supplement Figure 1 shows the 2021 cumulative mortality rates among indigenous peoples and the general population in Brazil in March, June and September 2021, overall and by geographic region, as presented in official reports.<sup>26</sup> The 2021 cumulative mortality rates



**Figure 2.** Brazilian indigenous health network organization (translated from the Brazilian Ministry of Health).<sup>17</sup>

among indigenous populations were seemingly lower in every Brazilian region and period, suggesting a beneficial impact of the prioritization in the vaccination strategy. However, there are important pitfalls that should be considered for the interpretation of this data. First, there is a presumably strong protective effect of the younger age structure among indigenous groups compared to the general population for COVID-19 mortality. Unfortunately, due to the absence of updated census data concerning the Brazilian age structure, it was not possible to calculate age standardized mortality ratios. Second, official COVID-19 epidemiological reports of COVID-19 among indigenous populations considered incidence and mortality events in indigenous populations living in villages only. Third, it is likely that underreporting of COVID-19 cases and deaths were more frequent in indigenous populations compared to the general population due to scarcer diagnostic resources in distant communities.<sup>28</sup> It is also important to point out that Brazil had one of the world's highest COVID-19 incidence and mortality rates in 2021<sup>29</sup>; thus, data showing lower mortality among indigenous populations should not be interpreted as a triumph.

Figure 5 contrasts 2021 reported cumulative incidence rates per 100,000 inhabitants among indigenous and the general Brazilian population. COVID-19 reported incidence was higher among indigenous groups despite the prioritization in the vaccination

program, suggesting that non-pharmacological interventions to prevent the spread of COVID-19 were less efficiently and insufficiently implemented in these populations.

### Discussion

In this descriptive analysis, we showed important heterogeneities in the COVID-19 vaccination coverage across different indigenous health districts, with lower overall coverage compared to that observed among older adults, even though both groups were prioritized and started vaccination in the same calendar period. We also showed that cumulative incidence rates were higher among indigenous populations compared to the general population in Brazil in 2021. We also found seemingly lower mortality rates; however, a direct comparison of COVID-19 mortality among indigenous populations and the general population should not be performed without accounting for differences in age structure and presumably higher underreporting of cases and deaths. Collectively, our findings suggest that although a beneficial effect likely resulted from the prioritization in the COVID-19 vaccination program, additional strategies to improve vaccine coverage and enhance non-pharmacological prevention of COVID-19 could have further mitigated the detrimental impact of the pandemic in this vulnerable population. The historical health inequities

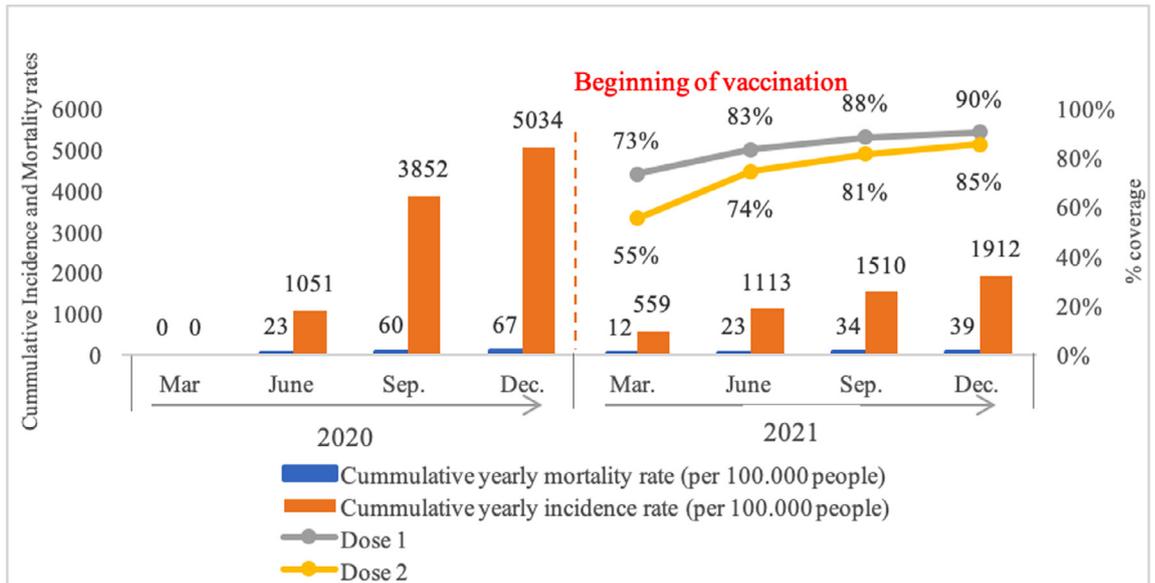


Figure 3. Total indigenous vaccination coverage, cumulative yearly incidence, and mortality rates per 100,000 people.

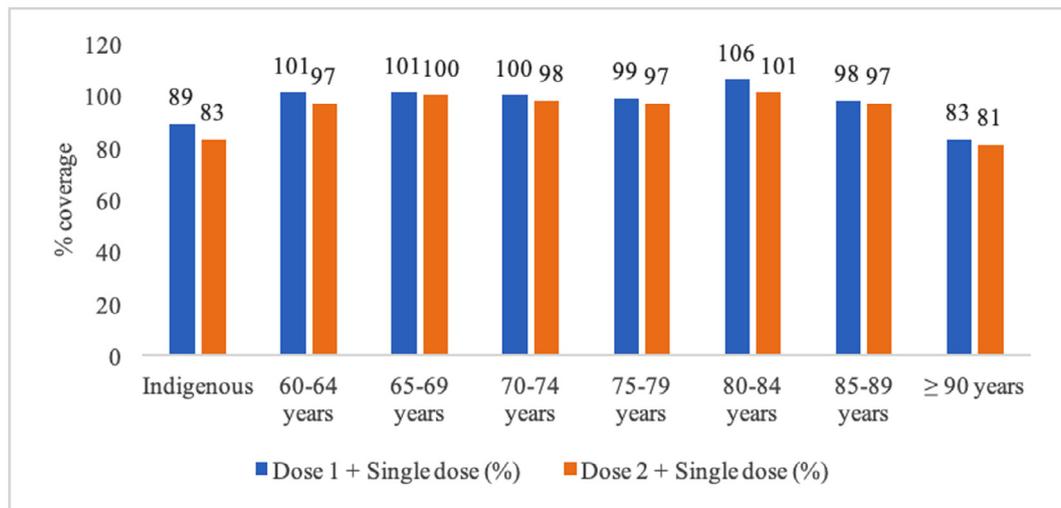
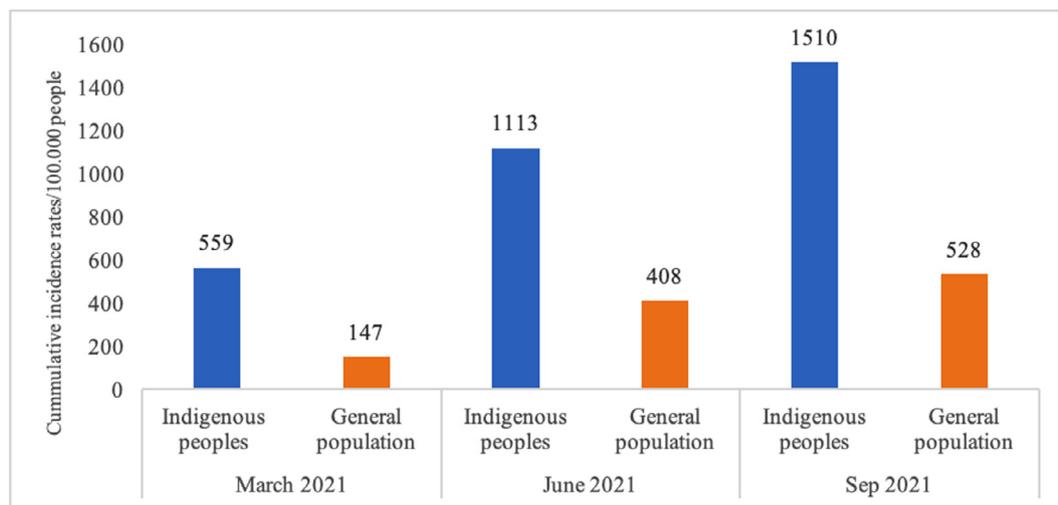


Figure 4. Percentages of vaccination coverage in indigenous peoples and older adults in Brazil at the 48th epidemiological week (November 28<sup>th</sup>-December 4<sup>th</sup>, 2021).

faced by the indigenous peoples in Brazil are now exacerbated under the effects of COVID-19, and attest to the urgent need of tailored interventions to reduce these disparities.

Several known factors can contribute to a lower vaccination coverage and higher incidence rates among indigenous peoples in the context of COVID-19. Many indigenous groups are living in isolation or in distant communities, accessible only through fluvial or air travel, or requiring several days of foot travel in the deep forest; such access barriers are challenges to both the

vaccination program and to medical support when needed. Despite these difficulties, the Brazilian Immunization Program achieved higher vaccination coverage for other conditions among indigenous peoples in the past. For example, during the H1N1 pandemic, nearly 90% of the overall indigenous population underwent vaccination in a three-month course,<sup>30</sup> suggesting that geographic isolation alone cannot justify the outcomes observed during the COVID-19 pandemic in this population. Importantly, the COVID-19 vaccination campaign in Brazil lacked a coordinated strategy of



**Figure 5.** Cumulative incidence rates among indigenous peoples and the general Brazilian population in 2021.

information that could help encourage vaccine adherence. In fact, Brazilians received conflicting and inaccurate information from the president himself.<sup>31–34</sup> Simultaneously, as seen in other parts of the world, a flow of fake news concerning the vaccine safety and efficacy invaded the indigenous territory mainly through word of mouth and social media sources. The scarcity of qualified guidance and the difficulties in discriminating trustworthy from fake information were additional elements that contributed to a lower than optimal vaccination coverage.<sup>8</sup>

The PNASPI policy created by the Ministry of Health of Brazil in 2000 included strategies to overcome specific challenges and accommodate cultural and social idiosyncrasies of indigenous communities. However, over the years, this system has been facing several operational and implementation difficulties. Consequently, improvements in health indicators of indigenous peoples have been very scarce. This poorly implemented policy was not able to respond with the necessary resources in an extreme situation such as the COVID-19 pandemic, resulting in a lower than optimal vaccination coverage and high mortality rates.<sup>35</sup>

Given the limited effectiveness of health policies implemented by the Federal government against COVID-19 in Brazil, several actions led by the civil society, including indigenous organizations, researchers, and non-governmental organizations, have been essential in mitigating the impacts of the pandemic among indigenous peoples in Brazil. We highlight among these initiatives the action organized by the Coordination of Indigenous Peoples of Brazil (APIB), which gave rise to the process of Claim of Noncompliance with a Fundamental Precept (*Arguição de Descumprimento de Preceito Fundamental*: ADPF) number 709 in the Federal Supreme Court (STF). This action revealed the Federal

government's omission regarding COVID-19 prevention and care interventions targeting indigenous populations.<sup>36</sup>

Following the ADPF lawsuit, a mitigation plan for the pandemic was established in July 2020, where each DSEI, in coordination with SESAI and FUNAI, was responsible for implementing prevention and care strategies for indigenous peoples, including the provision of medical supplies, qualified human resources, and the COVID-19 vaccination program.

The reductions observed in cumulative incidence and mortality rates after the onset of the vaccination program, despite an overtly higher number of COVID-19 cases in 2021 compared to 2020 in Brazil,<sup>37</sup> demonstrates the importance of mass vaccination to reduce COVID-19 cases and mortality. Yet, although the indigenous populations received priority in the Brazilian vaccination campaign, incidence rates were higher than those seen in the general population in every Brazilian geographic region, and mortality rates were still high, despite the younger age structure of indigenous peoples. Difficulties in access to healthcare, along with characteristics of social organization and genetic susceptibilities intrinsic to indigenous peoples, may have contributed to these outcomes.<sup>4,38</sup>

This study had a few limitations. We used secondary data from public datasets, which often have inconsistencies, and are likely subject to underreporting of COVID-19 cases and deaths. Since the beginning of the pandemic, several regions in Brazil faced scarcity of medical supplies and tests, contributing to underdiagnosis of COVID-19 cases, particularly in remote areas.<sup>28</sup> Measurements of vaccine coverage may be inaccurate due to incorrect estimates of the target population; this could have occurred across the country since the most recent census was reported more than 11 years ago. However,

estimates of the target population may be even less precise among indigenous groups living in distant regions. Additionally, the indigenous populations reported for each DSEI comprise all individuals living in villages, but does not account for all individuals living in urban areas. Due to the absence of updated census information, were unable to calculate age and sex-standardized mortality ratios that would allow a more appropriate comparison of mortality rates. Finally, we analysed data from indigenous peoples in Brazil collectively, disregarding important heterogeneities across different populations and territories. Nevertheless, our study suggests that social and health inequities affecting the indigenous peoples in Brazil have been aggravated during the COVID-19 pandemic.

The burden of COVID-19 among indigenous peoples in Brazil could have been mitigated by increasing the effectiveness of existing policies and improving communication regarding the COVID-19 vaccine and other mitigation strategies. Improvements in the structure and organization of indigenous healthcare strategies should be implemented, considering the complex cultural and social characteristics of indigenous peoples, to preserve the health and the existence of the original peoples of Brazil.

### Contributors

All authors conceptualized the study. FCGM and VIAS wrote the manuscript. FCGM and MMF verified the underlying data. All authors revised and approved the final version of the manuscript and had final responsibility for the decision to submit for publication.

### Data sharing statement

This study used publicly available data. All data sources have been indicated as references.

### Editor note

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### Declaration of interests

We declare no conflicts of interest.

### Acknowledgements

None to declare.

### Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.lana.2022.100319.

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