Cogitare Enfermagem

ORIGINAL ARTICLE

Immunization against COVID-19: impact on incidence, hospitalization, and mortality rates between 2020 and 2022*

HIGHLIGHTS

1. 84,194 cases, 4,425 hospitalizations, and 1,252 deaths recorded due to COVID-19.
2. Hospitalization rate per 100,000 inhabitants decreased from 929.25 in 2021 to 135.77 in 2022.
3. Mortality rate per 100,000 inhabitants fell from 291.28 in 2021 to 43.99 in 2022.
4. The progress of vaccination reduced hospitalizations and mortality.

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ABSTRACT

Objective: To analyze the impact of COVID-19 immunization on incidence, hospitalization, and mortality rates between 2020 and 2022. **Method:** Ecological time series study using secondary data from the *Notifica COVID-19* and National Immunization Program systems. All confirmed cases, hospitalizations, and deaths were considered, with rates calculated per 100,000 inhabitants. The indicators were compared with the evolution of vaccination coverage over time, measured by the cumulative number of doses administered per epidemiological week. **Results:** There were 84,194 cases, 4,425 hospitalizations, and 1,252 deaths. Hospitalization fell from 929.25 in 2021 to 135.77 in 2022, while mortality decreased from 291.28 to 43.99 per 100,000 inhabitants. A temporal association was found between vaccination progress and reductions in indicators. **Conclusion:** Immunization was instrumental in reducing hospitalizations and deaths, reinforcing the importance of specific strategies in border regions.

DESCRIPTORS: COVID-19; Vaccination; Incidence; Mortality; Hospitalization.

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INTRODUCTION

The COVID-19 pandemic has caused profound changes in health, cultural, financial, and governmental systems, with initial control measures heavily based on non-pharmaceutical interventions[1]. Among these, the total or partial closure of borders stands out, adopted in several regions, such as the European Union and Latin America, to restrict the movement of people and goods[2-3]. However, the COVID-19 pandemic has had a strong impact on land border regions in Brazil, where the intense flow of people and goods has favored the rapid introduction and higher incidence of the disease[3-4].

Brazil has recorded 38,694,221 confirmed cases and 710,966 deaths from COVID-19, of which 2,997,201 infections and 46,667 deaths occurred in Paraná[5]. In Foz do Iguaçu, a border municipality in the western region of the state, there were 87,249 cases and 1,308 deaths[6]. Located in the tri-national land border region between Brazil, Argentina, and Paraguay, the cities of Foz do Iguaçu, *Puerto Iguazú, and Ciudad del Este* similarly faced an uneven start to vaccination, due to the different national policies adopted by the three countries[7].

The municipality of Foz do Iguaçu has tourism as one of its main economic pillars, being the second most sought-after Brazilian destination by foreigners and home to the largest free trade zone in Latin America. In this context, the closure of borders and social isolation measures adopted during the pandemic have had wide-ranging and interdependent repercussions. In the economic field, job losses and reduced income stood out; in the health field, there were direct impacts on the population's health in the border region, with an increase in physical and mental health problems and greater pressure on local health services[8].

This disparity, coupled with insufficient doses to fully serve priority groups, highlighted the lack of a joint and cooperative immunization strategy at the border[7]. Epidemiological analyses show temporal similarity in the spread of COVID-19 across countries in the border region, reinforcing cross-border interconnection in the transmission of SARS-CoV-2[9].

The literature available to date indicates, based on an ecological study conducted at the federal level, that vaccination against COVID-19 had significantly reduced cases and deaths between 2020 and 2022[10]. Although there are studies on the impact of vaccination in border regions, these focus mainly on hospitalizations and deaths that occurred between 2020 and 2021[11], highlighting gaps in current knowledge about vaccination's effect on case reductions in these regions.

In this sense, the objective of this article was to analyze the impact of COVID-19 vaccination on incidence, hospitalization, and mortality rates in the municipality of Foz do Iguaçu from 2020 to 2022.

METHOD

This is an ecological study with temporal analyses based on secondary data from the COVID-19 suspected case reporting system. The study was described in accordance with the guidelines of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) initiative.

The study was conducted in Foz do Iguaçu, a municipality in western Paraná, Brazil, with an area of 609.2 km², a population density of 468.5 inhabitants per km², and

an estimated population of 295,500 inhabitants in 2024. It has a Human Development Index of 0.751, classified as medium-high development[12]. Foz do Iguaçu is a city on the triple border with Argentina and Paraguay, marked by intense population flow and great cultural diversity, with more than 80 ethnic groups and a floating population of over one million people[13].

All confirmed COVID-19 cases, hospitalizations, and deaths recorded between 2020 and 2022 were considered. Only cases of COVID-19 among residents of Foz do Iguaçu were included, confirmed by surveillance methods, including laboratory confirmation, clinical-epidemiological confirmation, and confirmation based on clinical and imaging findings. The deduplication of records was conducted through a deterministic-probabilistic linkage procedure, using full name, date of birth, and mother's name as matching variables. After the automated step, a manual review of suspicious pairs was also performed to correct inconsistencies and resolve duplicates.

The epidemiological weeks corresponding to the date of symptom onset for cases, the date of hospitalization, and the date of outcome for deaths were used. The epidemiological week was adopted as the unit of analysis to reduce fluctuations in daily reporting and provide a more stable representation of SARS-CoV-2 transmission dynamics. Information was also collected on the number of COVID-19 vaccine doses administered between the epidemiological weeks of 2021 and 2022, using the date of vaccine dose administration to assign the corresponding epidemiological week.

Information on the number of confirmed cases, hospitalizations, and deaths from COVID-19 was obtained from the *Notifica COVID-19* database of the municipality of Foz do Iguaçu. In Paraná, the State Health Secretariat (SESA/PR) developed the *Notifica COVID-19* platform to monitor suspected and confirmed COVID-19 cases. Subsequently, the information collected by this state mechanism was integrated into the national e-SUS *Notifica* database, the system responsible for receiving reports of non-severe cases of COVID-19 at the federal level[14].

Information regarding the doses of COVID-19 vaccines administered was obtained from the National Immunization Program Information System (SI-PNI, acronym in Portuguese), the official platform used to record and monitor vaccination activities throughout the country. To calculate the rates, population estimates provided by the Brazilian Institute of Geography and Statistics (IBGE, acronym in Portuguese) for the respective years of the period analyzed were used[12].

Incidence, hospitalization, and mortality rates per 100,000 inhabitants were calculated using population estimates provided by the Brazilian Institute of Geography and Statistics (IBGE) for the corresponding years as the denominator. Information on COVID-19 vaccination refers to the cumulative number of doses administered in the municipality per epidemiological week, regardless of vaccine type used.

A descriptive temporal analysis was performed using the weekly historical series, to identify peaks in the occurrence of COVID-19 cases, hospitalizations, and deaths throughout the period, by epidemiological week. Additionally, the evolution of standardized rates per 100,000 inhabitants was examined in association with the cumulative number of vaccine doses administered, with the aim of characterizing the epidemiological dynamics of the disease and the progression of vaccination coverage in the municipality of Foz do Iguaçu. The organization, processing, and analysis of the data were conducted in Python (version 3), using the Pandas library for database manipulation and *Matplotlib* for graphical visualizations.

This research was ethically reviewed by the Human Research Ethics Committee of the State University of Western Paraná and approved with a Certificate of Ethical Review, opinion number 6,785,772.

RESULTS

During the period analyzed, Foz do Iguaçu (PR) recorded 84,194 confirmed cases of COVID-19, 4,425 hospitalizations, and 1,252 deaths. The annual distribution showed an increase in the number of cases, from 19,513 in 2020 to 26,945 in 2021 and 37,736 in 2022. Hospitalizations for COVID-19 were 1,350 in 2020 and 2,683 in 2021, followed by a significant reduction to 392 in 2022. Deaths followed a similar pattern, falling at the end of the period, totaling 284 in 2020, 841 in 2021, and 127 in 2022. The vaccination campaign began in 2021, when 473,507 doses were administered, increasing to 206,778 in 2022 (Table 1).

Table 1. Number of cases, hospitalizations, and deaths from COVID-19. Foz do Iguaçu, Paraná, Brazil, 2020–2022

Variables	Year		
	2020	2021	2022
Quantity (n)			
Cases	19.513	26.945	37.736
Hospitalizations	1.350	2.683	392
Deaths	284	841	127
Doses administered	0	473.507	206.778
Population	288.726	290.453	291.906
Indicators (per 100,000 inhabitants)			
Incidence	6,758.31	9,332.28	13,069.83
Hospitalization	467.57	929.25	135.77
Mortality	98.36	291.28	43.99

Source: The authors (2022).

Between 2020 and 2022, there was variation in the timing of case, hospitalization, and death peaks. In 2020, the peak of 1,296 cases and 85 hospitalizations occurred in epidemiological week 47, while the peak of 24 deaths occurred in epidemiological week 53. In 2021, the peaks were recorded in epidemiological week 07 for cases (1,611), epidemiological week 10 for hospitalizations (122), and epidemiological week 12 for deaths (58). As for 2022, the number of cases increased significantly, peaking in epidemiological week 03 (7,319), followed by 61 hospitalizations and 19 deaths in epidemiological week 04 (Table 2).

Figure 1 illustrates the temporal evolution of the incidence rate of COVID-19 cases per 100,000 inhabitants and the cumulative number of COVID-19 vaccine doses administered between 2020 and 2024. A total of 84,194 cases were recorded during the period, with three peaks: the first in epidemiological week 47 of 2020 with 1,296 cases, the second in epidemiological week 07 of 2021 with 1,611 cases, and the third in epidemiological week 03 of 2022 with 7,319 cases and a rate of 2,507.31 per 100,000 inhabitants, during the period of circulation of the *Omicron* variant. Vaccination began in EW 3 of 2021, totaling 680,285 doses administered during the period, with milestones of 200,000 doses in EW 29 of 2021, 400,000 in EW 43 of 2021, and 600,000 in EW 17 of 2022 (Figure 1).

Table 2. Epidemiological week with peak cases, hospitalizations, and deaths from COVID-19. Foz do Iguaçu, Paraná, Brazil, 2020–2022

Variables	Year		
	2020	2021	2022
Peaks	**n**	**n**	**n**
	(WK)	**(WK)**	**(WK)**
Cases	1	2	7,319
	(2020-47)	(2021-07)	(2022-03)
Hospitalizations	85	122	61
	(2020-47)	(2021-10)	(2022-04)
Deaths	24	58	19
	(2020-53)	(2021-12)	(2022-04)

Source: The authors (2022).
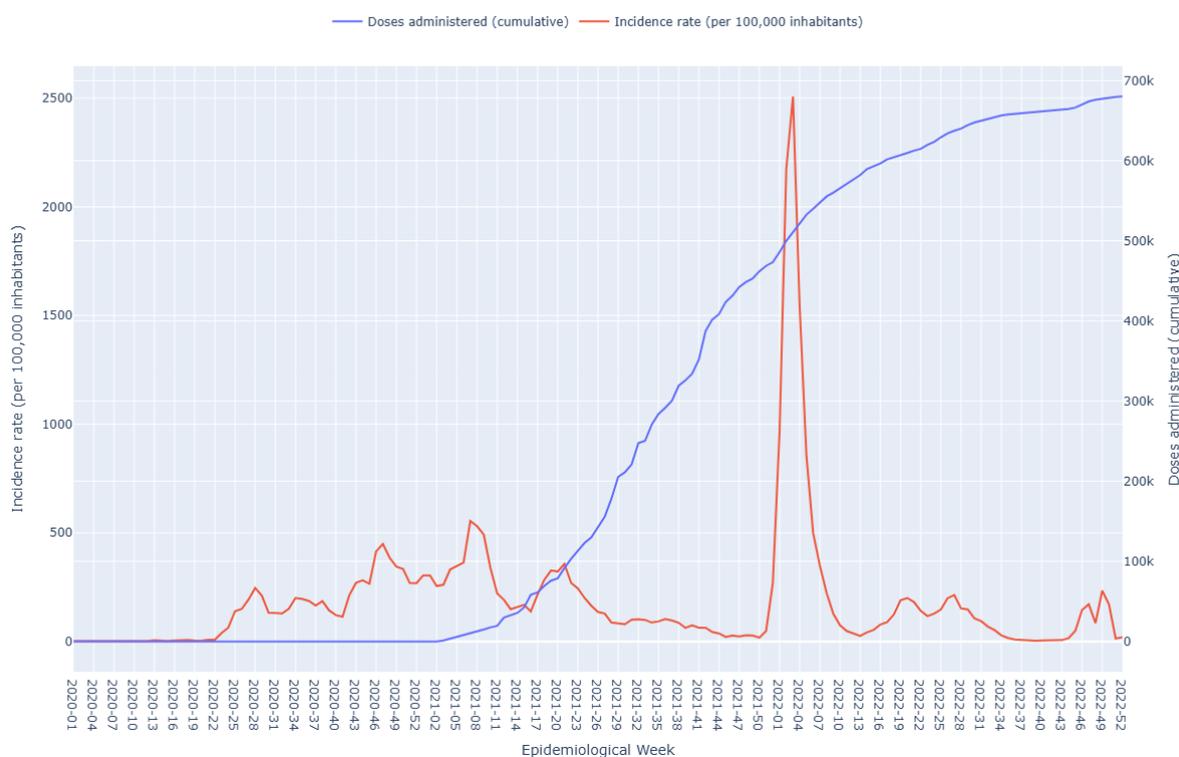
Figure 1. Incidence rate (per 100,000 inhabitants) of COVID-19 and number of COVID-19 vaccine doses administered (cumulative) by epidemiological week. Foz do Iguaçu, Paraná, Brazil, 2020-2022
Source: The authors (2022).

Figure 2 presents the evolution of the COVID-19 hospitalization rate (per 100,000 inhabitants) relative to the cumulative number of vaccine doses administered, according to epidemiological weeks between 2020 and 2022. During this period, 4,533 hospitalizations were recorded, peaking in EW 10 of 2021 (122 hospitalizations; 42.00 per 100,000 inhabitants). The intersection point between the curves occurred in EW 29 of 2021, coinciding with the expansion of vaccination coverage, especially among adults, and the beginning of a consistent shift in hospitalization patterns. Until then, there had been sharp, recurring peaks that overwhelmed the healthcare system. After this

milestone, hospitalizations declined progressively and sustainably. The last significant peak occurred in week 7 of 2022, associated with the spread of the *Omicron* variant, but despite the abrupt increase in cases, it was less intense and shorter compared to previous peaks that occurred before the expansion of immunization.
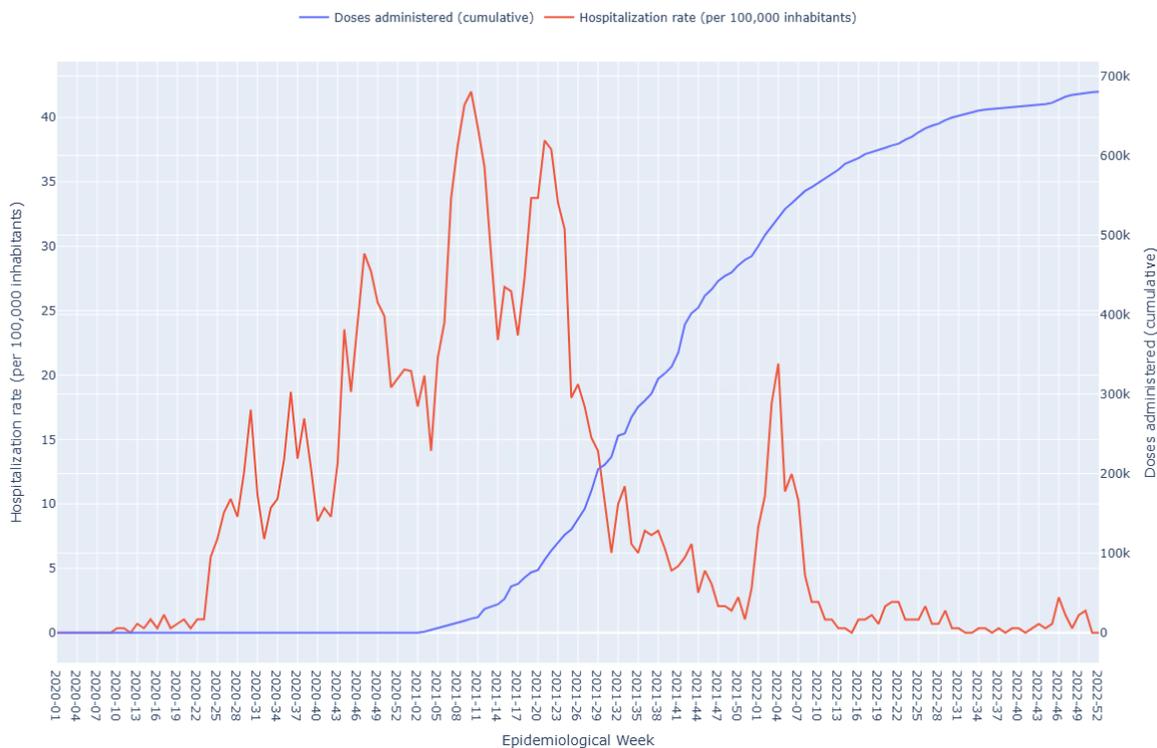

Figure 2. Hospitalization rate (per 100,000 inhabitants) due to COVID-19 and number of COVID-19 vaccine doses administered (cumulative) by epidemiological week. Foz do Iguaçu, Paraná, Brazil, 2020-2024
Source: The authors (2022).

Figure 3 shows the evolution of the COVID-19 mortality rate (per 100,000 inhabitants) relative to the cumulative number of vaccine doses administered, by epidemiological week, between 2020 and 2022. During this period, 1,252 deaths were recorded, peaking in WK 12 of 2021 (58 deaths; 19.97 per 100,000 inhabitants). WK 26 of 2021 marks the intersection of the mortality and vaccination coverage curves, indicating a transition phase in the pandemic: vaccination had already reached significant levels and began to reflect a consistent downward trend in death rates after months of record-high mortality. The last significant peak occurred in week 04 of 2022, during the Omicron variant's spread. Although associated with a significant increase in cases, mortality did not reach the magnitude observed in previous periods and was lower and shorter than in the pre-vaccination period.
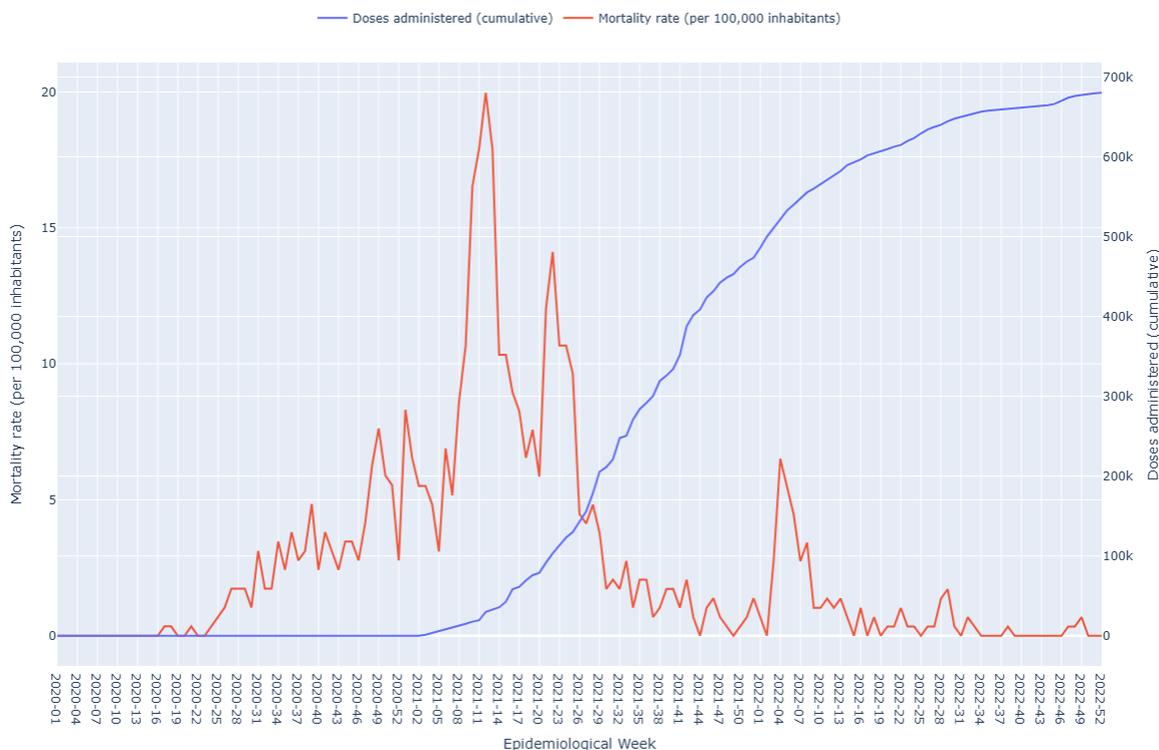
Figure 3. COVID-19 mortality rate (per 100,000 inhabitants) and number of doses administered against COVID-19 (cumulative) by epidemiological week. Foz do Iguaçu, Paraná, Brazil, 2020-2022
Source: The authors (2022).

DISCUSSION

The findings of this study show the trajectory of COVID-19 incidence rates, hospitalizations, and mortality in Foz do Iguaçu between 2020 and 2022, revealing three successive waves of varying magnitudes throughout the period. The second wave, in 2021, saw the highest peaks in severe cases and deaths, indicating high viral transmission and greater clinical severity at that moment. In 2022, although there was a more significant volume of infections, driven by the circulation of the *Omicron* variant, there was a sharp decline in the most severe outcomes, accompanying the expansion of vaccination coverage that began in the municipality in 2021. This behavior demonstrates a growing dissociation between the occurrence of cases and severity, suggesting that the advance of immunization played a decisive role in reducing hospitalizations and deaths, even in the face of intense community spread[10-11].

The state of Paraná adopted strict measures to contain COVID-19, notably State Decree No. 4,230 of March 2020, while the municipality of Foz do Iguaçu supplemented these actions through Municipal Decree No. 27,994/2020, even before the confirmation of local cases, demonstrating a preventive stance that was later adjusted with the easing of restrictions starting in May 2020, through Decree No. 28,103, which began to consider the spatial distribution of morbidity and mortality to define actions in specific areas of the city[9,11].

During the first wave of COVID-19 in Brazil, which occurred between February and November 2020, the southern region had an incidence rate of approximately 200 to 300 cases per 100,000 inhabitants during the period[10]. The findings of this study indicate an incidence rate of 500 cases per 100,000 inhabitants during the first wave of COVID-19 in Foz do Iguaçu, indicating a higher risk of infection at the border. Population-based

serological surveys conducted in Foz do Iguaçu indicate high SARS-CoV-2 circulation during the same period, reinforcing a high transmission of the virus[15].

In response to the COVID-19 pandemic, Decree No. 28,148, dated May 20, 2020, established 17 health checkpoints at strategic locations in Foz do Iguaçu, considering its border profile and the presence of imported and community transmissions. The objective was to identify suspected cases early and contain the spread of the disease[2]. The indicators of deaths from COVID-19 in Foz do Iguaçu were slightly higher than those observed in the southern region and Brazil[10], but with a different temporal behavior, characterized by the maintenance of cases between May 2020 and July 2021.

During this period, which coincided with the end-of-year festivities and Carnival, hotels in the city were 95% full, and there was also a significant increase in the transmissibility and lethality of the disease, possibly associated with the circulation of the Delta variant and new variants in the country[11]. During this period, approximately 50% of hospitalizations in Foz do Iguaçu resulted in death. Given the severity of the situation, Decree No. 6983 was published, suspending in-person classes and non-essential activities and instituting a curfew from 8 p.m. to 5 a.m., effective until March 8, 2021[11].

Following the emergency approval of the CoronaVac® and AstraZeneca vaccines, Brazil's COVID-19 vaccination campaign began in January 2021 with a limited number of doses, initially targeting the groups most at risk of the disease. In urban border areas, considered high risk for the introduction of new variants, mass vaccination was implemented about six months after the start of the campaign in the rest of the country[3]. Vaccination in Foz do Iguaçu began with frontline health professionals and elderly people in long-term care facilities. At the start of vaccination, the border region between Brazil, Paraguay, and Argentina was experiencing the most severe phase of the pandemic, marked by high rates of hospitalizations and deaths from COVID-19[11].

With the progress of immunization in the municipality, there was a marked reduction in COVID-19 cases, especially after reaching 100,000 doses administered in June 2021. Evidence at the federal level indicates a similar pattern, with a drop in cases starting at 30% vaccination coverage[10]. The progress of the vaccination campaign in Foz do Iguaçu was associated with a substantial reduction in COVID-19-related hospitalizations and deaths. However, even with the progressive increase in vaccination coverage, it was not possible to stop the occurrence and spread of cases of the *Omicron* variant, which is highly transmissible but less lethal, affecting the southern region more[10].

According to the data from this study, the peak of the third wave of COVID-19 was recorded in the third epidemiological week of 2022, totaling 7,319 cases. Luz and colleagues, when analyzing the incidence of COVID-19 in the 9th Regional Health District and in the neighboring regions of Paraguay and Argentina, identified that the peak of cases occurred in the same weeks: first in the Brazilian region, in epidemiological week 3 of 2022; then in Paraguay, also in the third week; and finally, in Argentina, in the fourth week of 2022; demonstrating the cross-border interconnection in the spread of SARS-CoV-2[9,11].

The closure of the Friendship Bridge (Brazil-Paraguay) and the Fraternity Bridge (Brazil-Argentina) in March 2020 was an important measure to contain the virus by encouraging social distancing, as recommended by the World Health Organization[14]. The reopening of the borders with Paraguay and Argentina led to an increase in COVID-19 cases in Foz do Iguaçu, due to the greater movement of people, although the impact was less at the border with Argentina because of stricter health rules and higher immunization rates among the population[16].

Research in Brazil and Argentina shows that although closing borders helped control the pandemic, it damaged the economies and mental health of those living in these regions, which are characterized by strong social and economic ties[14]. In Paraguay, even with initial control of the pandemic through strict quarantine, the situation worsened with the migration crisis at the Friendship Bridge. At the end of April, Paraguayan nationals arriving from Brazil were allowed to enter the country after humanitarian pressure. Many were taken to shelters, where around 80% tested positive for COVID-19, contributing to a rise in cases in the following weeks[17].

These events highlight the complexity and fragility faced in border regions, especially when considering the limitations of health services in responding effectively to situations involving population displacement, health emergencies, and social vulnerabilities. This problem became even clearer with the Action Plan: Vaccination Strategy at the Borders 2022, which highlights the need for specific strategies to ensure fair access to vaccination and control of vaccine-preventable diseases, especially in a context of declining vaccination coverage in Brazil since 2016, aggravated by the pandemic and the intense movement of people in these territories[18-19]. It is relevant to note that low vaccination coverage in these regions poses a high risk to public health, exposing the population to possible outbreaks and epidemics, with negative impacts on the community and an overload on health services[17].

Border regions, characterized by intense population mobility, continuous transnational interactions, and marked socioeconomic inequalities, present challenges to health systems. These factors increase health vulnerabilities and constitute territorial determinants that directly influence disease dynamics[3-4] in the Brazil-Argentina-Paraguay tri-border area. These specificities translate into greater exposure to migratory flows, differences in surveillance strategies, and unequal capacities to respond among countries. Added to the social fragilities and economic pressures typical of these territories, such as dependence on cross-border activities, high labor informality, and limited access to essential services, these asymmetries create an environment conducive to rapid viral spread and a consequent increase in demand on local services[7-10].

An important limitation of this study is the quality of data on the number of COVID-19 cases, which was affected by several factors, such as the absence of mass testing and the lack of detailed records in information systems, especially in the early months of the pandemic[10]. However, recent findings indicate good performance of COVID-19 surveillance systems in the southern region of the country, reducing the limitations of the data quality used in this study [20]. Another relevant limitation in understanding the phenomenon was the lack of a distinction between vaccine types, which made it difficult to analyze the relationship between vaccination coverage and COVID-19 outcomes because official criteria for defining complete and incomplete immunization schedules changed during the study period. It should be noted that there is a scarcity of studies that incorporate the border variable or are applied to border regions. These are essential for revealing specific dynamics of immunization and viral spread, contributing to improved surveillance policies and a more accurate response from local health systems, especially in triple-border municipalities. An important limitation of this study is the quality of data on the number of COVID-19 cases, which is affected by several factors, such as the absence of mass testing and the lack of detailed records in information systems, especially in the early months of the pandemic[10]. However, recent findings indicate good performance of COVID-19 surveillance systems in the southern region of the country, reducing the limitations of the data quality used in this study[20]. Another relevant limitation to understanding the phenomenon was the lack of distinction between the types of vaccines administered. This made it difficult to analyze the relationship between vaccination coverage and COVID-19 outcomes, because official changes in the criteria for defining complete and incomplete immunization schedules

occurred during the study period. It is noteworthy that there is a scarcity of studies that incorporate the border variable or are applied to border regions, which are essential for revealing specific dynamics of immunization and viral spread, contributing to improving surveillance policies and a more accurate response by local health systems, especially in triple border municipalities.

The epidemiological analysis of COVID-19 in Foz do Iguaçu identified three distinct epidemic waves, each influenced by different local and contextual factors. The first wave reflected the population's low immunity, allied with the presence of vulnerable groups. The second wave was marked by the reopening of the International Friendship Bridge and the circulation of more transmissible variants, which increased hospitalizations and deaths. The third wave coincided with holiday periods and the spread of the *Omicron* variant, resulting in a high number of cases, but with lower lethality.

It was observed that vaccination progress contributed significantly to reductions in hospitalizations and deaths, despite the persistence of viral transmission in the border region. Furthermore, the triple border context highlighted specific challenges related to population mobility and the vulnerability of local health services. These findings reinforce the importance of surveillance and immunization strategies tailored to the particular characteristics of border regions to mitigate the impacts of pandemics.

CONCLUSION

The research found that immunization played a strategic role in reducing hospitalizations and deaths in the triple border territories, where intense population flows and heterogeneity in health policies across countries amplify challenges and reinforce the need for strategies that expand vaccination coverage, improve monitoring, and strengthen cooperation between neighboring countries. The findings point to direct implications for subnational and cross-border health surveillance, reinforcing the need for coordinated monitoring models, timely information sharing, and coordinated responses between municipalities and neighboring countries. Vaccination reaffirms itself not only as an instrument of individual protection but also as a structuring axis of regional health security, helping mitigate serious outcomes and providing a more solid basis for public policies aligned with territorial specificities.

REFERENCES

1. Hale T, Angrist N, Hale AJ, Kira B, Majumdar S, Petherick A et al. Government responses and COVID-19 deaths: global evidence across multiple pandemic waves. PLoS One [Internet]. 2021 [cited 2025 Aug 1];16(7):e0253116. Available from: https://doi.org/10.1371/journal.pone.0253116

2. Leandro GCW, Luz LDP, Arenhart CGM, Izuka ADL, Doldan RV, Bom CAG, Britto AS. Intervenções não farmacológicas como medidas de enfrentamento à pandemia de Covid-19 em municípios de fronteira. Rev Saúde Pública Paraná [Internet]. 2020 [cited 2025 Aug 1];3(Suppl 1):266-75. Available from: https://doi.org/10.32811/25954482-2020v3sup1p266

3. Pêgo B, Moura R, Nunes M, Krüger C, Moreira P, Ferreira G et al. Pandemia e fronteiras brasileiras: análise a evolução da COVID-19 e proposições [Internet]. Brasília: Instituto de Pesquisa Econômica Aplicada (Ipea); 2020 [cited 2020 Jun 26]. (Nota Técnica, n.16). Available from: https://www.ipea.gov.br/portal/images/stories/PDFs/nota_tecnica/200521_n_16_dirur.pdf

4. Nagamine LY, Ferreira G, Gruger C, Moura R. Disseminação da Covid-19 nas faixas de fronteira terrestre e litorânea do Brasil. Rev Tempo Mundo [Internet]. 2021 [cited 2025 Aug 1];23:203-33.

Available from: https://repositorio.ipea.gov.br/bitstream/11058/10435/1/Tempo_Mundo_n23_Artigo8_disseminacao_covid19_faixas.pdf

5. Secretaria de Estado da Saúde (SESA-PR). Coronavírus (COVID-19) [Internet]. Curitiba (PR): Secretaria de Estado da Saúde; 2024 Mar 25 [cited 2024 Mar 26]. Available from: https://www.saude.pr.gov.br/Pagina/Coronavirus-COVID-19

6. Secretaria Municipal da Saúde (Foz do Iguaçu). Vigilância Epidemiológica - Painel Coronavírus: Foz do Iguaçu [Internet]. Foz do Iguaçu: Secretaria Municipal da Saúde; 2023 [cited 2024 Aug 10]. Available from: https://catve.com/files/169219681464dcdfce3a68d.pdf

7. Alves TAL. Enfrentamento da Covid-19 em região transfronteiriça: a importância da cooperação entre as cidades de Foz do Iguaçu, Ciudad del Este e Puerto Iguazú. Espirales [Internet]. 2021 [cited 2024 Aug 10];5(2 Edição Especial):124-129. Available from: https://revistas.unila.edu.br/espirales/article/view/2793

8. Silva-Sobrinho RA, Zilly A, da Silva RMM, Arcoverde MAM, Deschutter EJ, Palha PF, et al. Coping with COVID-19 in an international border region: health and economy. Rev Latino-Am Enferm [Internet]. 2021 [cited 2025 Aug 1];29:e3398. Available from: https://doi.org/10.1590/1518-8345.4659.3398

9. Luz LDP, Braga JU, Maciel EMGS. Detection of covid-19 epidemic waves and their interrelationships in the tri-border region between Brazil, Paraguay, and Argentina, 2020-2023: Covid-19 epidemic waves in the tri-border region. SciELO Preprints [Internet]. 2024 [cited 2025 Aug 1]. Available from: https://doi.org/10.1590/SciELOPreprints.10963

10. Moura EC, Cortez-Escalante J, Cavalcante FV, Barreto ICHC, Sanchez MN, Santos LMP. Covid-19: temporal evolution and immunization in the three epidemiological waves, Brazil, 2020-2022. Rev Saúde Pública [Internet]. 2022 [cited 2025 Aug 1];56:105. Available from: https://doi.org/10.11606/s1518-8787.2022056004907

11. Kunkel M, Gordillo EAF, Cicchelero LM, Porzsolt F, Meira MCR, Ferreira H, et el. Epidemic curves and the profile of patients hospitalized by COVID-19 in a border region. Rev Latino-Am Enferm [Internet]. 2024 [cited 2025 Aug 1];32:e4296. Available from: https://doi.org/10.1590/1518-8345.6772.4297

12. Instituto Brasileiro de Geografia e Estatística (IBGE). Cidades: Foz do Iguaçu [Internet]. Rio de Janeiro (RJ): IBGE; 2025 [cited 2025 Aug 1]. Available from: https://cidades.ibge.gov.br/brasil/pr/foz-do-iguacu/panorama

13. Meira MCR, Nihei OK, Moschini LE, Arcoverde MAM, Britto AS, Silva-Sobrinho RA, Muñoz SS. Influence of the weather on the occurrence of dengue in a triple-border Brazilian municipality. Cogitare Enferm [Internet]. 2021 Nov 4 [cited 2025 Aug 1];26:e76974. Available from: https://doi.org/10.5380/ce.v26i0.76974

14. Brasil. Ministério da Saúde. Secretaria de Vigilância em Saúde. Guia de vigilância epidemiológica: Emergência de Saúde Pública de Importância Nacional pela Doença pelo Coronavírus 2019 - COVID-19 [Internet]. Brasília (DF): Ministério da Saúde; 2022a [cited 2025 Aug 1]. Available from: https://www.gov.br/saude/pt-br/assuntos/saude-de-a-a-z/c/covid-19/publicacoes-tecnicas/guias-e-planos/guia-de-vigilancia-epidemiologica-covid-19/view

15. Viana K, Zarpelon L, Leandro A, Terencio M, Lopes R, Martins C, et al. Infection in asymptomatic carriers of SARS-CoV-2 can interfere with the achievement of robust immunity on a population scale. J Gen Virol [Internet]. 2021 Nov 17 [cited 2025 Aug 2];102(11):001684. Available from: https://doi.org/10.1099/jgv.0.001684

16. Suprinyak FH, Benito GAV, Nihei OK. Efeitos da reabertura de fronteiras terrestres na evolução espacial e temporal da COVID-19 em Foz do Iguaçu, 2020-2021. Hygeia Rev Bras Geogr Méd Saúde [Internet]. 2025 [cited 2025 Aug 1];21:e2131. Available from: https://doi.org/10.14393/hygeia2174219

17. Oliveira LK. Pandemia na fronteira: Foz do Iguaçu, Puerto Iguazú e Ciudad del Este. La Espada [Internet]. 2020 Jul [cited 2025 Aug 1];24:4-5. Available from: https://portal.unila.edu.br/revistas/la-espada

18. Nascimento LMD, Araújo ACM, Souza PCA, Matozinhos FP, da Silva TPR, Fernandes EG. Estratégia

do Ministério da Saúde do Brasil para aumento das coberturas vacinais nas fronteiras. Rev Panam Salud Publica [Internet]. 2024 [cited 2025 Aug 1];48:e31. Available from: https://doi.org/10.26633/RPSP.2024.31

19. Brasil. Ministério da Saúde. Plano de ação: estratégia de vacinação nas fronteiras - Agenda 2022 [Internet]. 2nd ed. Brasília (DF): Ministério da Saúde; 2022b [cited 2025 Aug 1]. Available from: https://www.gov.br/saude/pt-br/centrais-de-conteudo/publicacoes/svsa/vacinacao-imunizacao-pni/plano-de-acao-estrategia-de-vacinacao-nas-fronteiras-agenda-2022/view

20. Leandro GCW, Cicchelero LM, Massago M, Oliveira DG, Bortoli DM, Murillo RSG, et al. Evaluation of the acute respiratory infections surveillance system and associated factors: a cross-sectional study, Brazil, 2009-2021. Epidemiol Serv Saúde [Internet]. 2025 [cited 2025 Aug 2];34:e20240555. Available from: https://doi.org/10.1590/S2237-9622025v34e20240555.en

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