REVISTA HYGEIA **ISSN: 1980-1726**
https://seer.ufu.br/index.php/hygeia DOI: https://doi.org/10.14393/Hygeia2069006

EFFECTIVENESS OF LAND BORDER CLOSURES IN TWIN CITIES AIMING AT MITIGATING THE SPREAD OF SARS-COV-2 AND ASSOCIATION BETWEEN CITY'S CHARACTERISTICS AND COVID-19 INCIDENCE

EFICIÊNCIA DO FECHAMENTO DE FRONTEIRAS TERRESTRES EM CIDADES GÊMEAS PARA MITIGAR A DISSEMINAÇÃO DO SARS-COV-2 E ASSOCIAÇÃO ENTRE AS CARACTERÍSTICAS DAS CIDADES E INCIDÊNCIA DE COVID-19

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ABSTRACT

We investigated the effectiveness of closing land borders in Brazilian twin cities as a measure to mitigate the increase in Covid-19 cases. Our investigation comprised a controlled before-and-after study followed by a case-control study to evaluate associated factors influencing the rise in Covid-19 incidence. We utilized data encompassing all Covid-19 cases and deaths between August and December 2020. No association was found between border opening and the incidence rate neither among controls (381.00 [261.31-932.96] vs 394.64 [163.23–957.03] per 100,000 population, z=1.09, p=0.27), nor in the intervention group (246.89 [222.17–549.26] vs 231.70 [179.15–646.26] per 100,000 population, z=0.20, p=0.84). The same occurred regarding Covid-19 mortality rate in both control and intervention group (6.26 [2.09-14.66] vs 7.14 [2.88–16.79], z=0.53, p=0.59); (6.86 [5.23-16.54] per 100,000 population vs 4.43 [2.86-11.88] per 100,000 population, z=1.53, p=0.12), respectively. Subsequently, we found no association between population size, the presence of airports, distance between cities, border type, and the incidence of Covid-19. The lack of association between the reopening of international land borders and the characteristics of twin cities with the impact caused by Covid-19 should be considered when restricting the flow of people between twin cities during a pandemic.

Keywords: Twin Cities. Covid-19. International borders.

RESUMO

Investigamos a efetividade do fechamento de fronteiras terrestres em cidades gêmeas brasileiras como medida contra o aumento nos casos de Covid-19. Nossa investigação incluiu um estudo antes-e-depois controlado seguido de um estudo caso-controle para investigar fatores associados ao aumento na incidência de Covid-19. Utilizamos dados de todos os casos de Covid-19 e mortes entre agosto e dezembro de 2020. Não encontramos associação entre a abertura da fronteira e incidência nem dentre controles (381,00 [261,31-932,96] *vs* 394,64 [163,23-957,03] por 100.000 habitantes, z=1,09, p=0,27); e nem no grupo intervenção (246,89 [222,17-549,26] *vs* 231,70 [179,15-646,26] por 100.000 habitantes, z=0,20, p=0,84)). O mesmo ocorreu com a taxa de mortalidade (grupo controle (6,26 [2,09-14,66] por 100.000 habitantes *vs* 7,14 [2,88-16,79] por 100.000 habitantes, z=0,53, p=0,59); grupo intervenção (6,86 [5,23-16,54] por 100.000 habitantes *vs* 4,43 [2,86-11,88] por 100.000 habitantes, z=1,53, p=0,12)). Subsequentemente, não encontramos associação entre tamanho da população, presença de aeroportos, distância entre cidades gêmeas, tipo de fronteira, e a incidência de Covid-19. A falta de associação entre reabertura das fronteiras e as

Recebido em: 14/04/2023
Aceito para publicação em: 25/03/2024.

características das cidades gêmeas com o impacto causado pela Covid-19 deve ser considerada ao restringir o fluxo de pessoas entre cidades gêmeas durante uma pandemia.

Palavras-chave: Cidades gêmeas. Covid-19. Fronteiras internacionais.

BACKGROUND

Twin-cities are defined as municipalities that have an individual population greater than 2,000 inhabitants and that are separated by the international border line, either dry or fluvial, connected or not by infrastructure works (BRASIL,2016). These cities have become one of the priority targets in the development of public policies for the border zone, as they present great potential for economic, cultural and social interaction. However, despite these cross-border areas being also an important region to public health, it is still unclear whether restricting the flow of people between twin cities effectively controls a pandemic burden (AIKES; RIZZOTTO, 2018)

The international flow of people is a relevant aspect when thinking about the health of populations in the border region. This cross-border flow is exacerbated by the presence of a floating population, which does not settle for a long time in border cities, and by the pendulum migratory movement of people who cross the border daily for work (ALBUQUERQUE, 2008). In this context, in health geography, twin cities represent a sanitarily sensitive space, given the potential international circulation of diseases and vulnerability in relation to surveillance and control of emerging diseases (PEITER et al., 2018).

However, the lack of knowledge about the impact of border movement of people, especially in the face of pandemic threats, creates uncertainty regarding the measures adopted at international borders. Historically, states have responded to global health crises with border closures and restrictions on foreign travelers, and these are considered effective strategies for mitigating health crises. Still, the effectiveness of restricting the international movement of people in a pandemic scenario is unclear (KENWICK; SIMMONS, 2020).

The first cases of Covid-19 were detected in China in late 2019 (SCHROEDER et al., 2022; ZEISER et al., 2022). By March 11, 2020, when the World Health Organization (WHO) declared a Covid-19 pandemic, 121,386 cases and 4,371 deaths had been reported on all continents. Sars-Cov2, the cause of Covid-19, is a virus that causes respiratory infections and is characterized by high infectiousness and potentially lethal effects (PEGO et al., 2020; ROCHA et al., 2021). In reaction, governments implemented strategies to combat the transmission of the virus, such as social distancing and closing borders (MAGALHÃES; RONCONI; ASSIS, 2021; NETO; PENHA, 2017). In Brazil, international land borders were closed as of March 18, 2020 (PEGO et al, 2020).

Contrarily, the literature mentions that the available scientific evidence prior to the Covid-19 outbreak is limited but suggests that closing borders is an ineffective strategy to control pandemics. In fact, it is estimated that at the beginning of the pandemic, international travelers contributed more than 10% of the total Covid19 cases in 102 countries with no restrictions on the flow of people across international borders (RUSSELL et al.,2021). Thus, it is suggested that restricting the movement of travelers from countries with high virus prevalence would be sufficient to reduce exposure in many regions (RUSSELL et al., 2021).

The uncertainty of scientific evidence about the effectiveness of border movement restriction is a factor that hinders decision making regarding the movement of people during a pandemic. Nevertheless, when an outbreak occurs, policy makers make decisions based on incomplete information (KENWICK; SIMMONS, 2020). The Covid-19 pandemic scenario provides an opportunity to test the hypothesis that closing land borders reduces airborne transmission of communicable diseases. The objective of this research was to analyze the effectiveness of land borders closures in twin cities in mitigating the spread of Covid-19 cases and to verify the factors associated with the incidence of Covid-19 in Brazilian twin cities during the period of reopening of international land borders.

METHOD

Type of study

This is a controlled before-and-after study, with Brazilian municipalities as the unit of analysis, followed by a case-control study.

Participants

All twin cities in Brazil were eligible, and none were excluded. Brazil has 33 twin cities, namely, Oiapoque, Bonfim, Pacaraima, Tabatinga, Santa Rosa do Purus, Assis Brasil, Barracão, Dionísio Cerqueira, Itaqui, Porto Mauá, Porto Xavier, Santo Antônio do Sudoeste, Aceguá, Barra do Quarai, Chuí, Jaguarão, Quarai, Santana do Livramento, Brasileia, Cáceres, Epitaciolândia, Guajará-mirim, Corumbá, Bela Vista, Coronel Sapucaia, Foz do Iguaçu, Guaira, Mundo Novo, Paranhos, Porto Murtinho, Ponta Porã, São Borja and Uruguaiana.

The intervention group included Brazilian twin cities whose land border was reopened between September 1 and October 15, 2020, in total 19 twin cities opened their borders in that period: Aceguá, Barra do Quarai, Chuí, Jaguarão, Quarai, Santana do Livramento, Brasileia, Cáceres, Epitaciolândia, Guajará-mirim, Corumbá, Bela Vista, Coronel Sapucaia, Foz do Iguaçu, Guaira, Mundo Novo, Paranhos, Porto Murtinho, and Ponta Porã.

The control group comprised Brazilian twin cities whose land border remained closed during that period, altogether 14 Brazilian twin cities kept their land border closed during the study period: Oiapoque, Bonfim, Pacaraima, Tabatinga, Santa Rosa do Purus, Assis Brasil, Barracão, Dionísio Cerqueira, Itaqui, Porto Mauá, Porto Xavier, Santo Antônio do Sudoeste, São Borja and Uruguaiana.

Border cities are characterized by being a territory of permanent interactions between people from neighboring cities, from different nations, located in border regions, thus, border cities interact internationally in a more or less intense way, depending on the geographical proximity with reference to the border line. In this context, border cities are classified into three types: borderland cities, twin border cities, and conurbation border cities; however, it should be noted that such classification is not exclusive (PRADO; NETO, 2015).

Brazil has more than 16,885 kilometers of international borders. It is the country in the American continent that has the largest number of land borders, sharing borders with ten nations: Suriname, French, Guyana, Venezuela, Colombia, Peru, Bolivia, Paraguay, Argentina, and Uruguay, which border the states of Amapá, Pará, Roraima, Amazonas, Acre, Rondônia, Mato Grosso, Mato Grosso do Sul, Paraná, Santa Catarina, and Rio Grande do Sul (PEGO et al., 2017).

Figure 1 – Intervention group and control group, twin cities, Brazil

Border country / territory	**Twin Cities**
Intervention group twin cities that opened the borders between September 1 and October 15, 2020	
Uruguay	Aceguá Barra do Quarai Chuí Jaguarão Quarai São Borja Santana do Livramento Uruguaiana.
Bolívia	Brasileia Cáceres Epitaciolândia Guajará-mirim Corumbá
Paraguay	Bela Vista Coronel Sapucaia Foz do Iguaçu Guaira Mundo Novo Paranhos Porto Murtinho Ponta Porã.
Control group Brazilian twin cities that kept their land border closed during the study period	
French Guyana	Oiapoque
	Bonfim

Guyana	
Venezuela	Pacaraima
Colombia	Tabatinga
Peru	Santa Rosa do Purus Assis Brasil
Argentina	Barracão Dionísio Cerqueira Itaqui Porto Mauá Porto Xavier Santo Antônio do Sudoeste

Source: the authors.

Variables and Data Source

The independent variable was the clearance for international flow of people between twin cities (Figure 1) and the dependent variables were the Covid-19 incidence and mortality rates per municipality.

The Covid-19 incidence and mortality data in twin cities between August and December 2020 were obtained from the Covid-19 Case Panel in Brazil, which is managed by the Ministry of Health, while demographic data were collected from the Brazilian Institute of Geography and Statistics (IBGE). Two observations were conducted for each twin city, the initial one with data on new cases and deaths occurring over the approximately 30 days prior to the opening of the border, data for the post-border opening period were obtained approximately for the period from the 16th to the 45th day after the border opening. The 15-day period immediately after the opening of the border was not considered, as much of the information from this period would have been from infections that occurred prior to the opening of the border (Figure 2).

Figure 2 – Twin City, Brazil

Country	**Initial observation**	**Final observation**
Bolivia and Uruguay	01/08/2020 to 01/09/2020	15/09/2020 to 15/10/2020
Argentina and Peru	01/08/2020 to 01/09/2020	15/09/2020 to 15/10/2020
Paraguay	15/09/2020 to 15/10/2020	30/10/2020 to 30/11/2020
Colombia, Venezuela, Guyana and French Guyana	15/09/2020 to 15/10/2020	30/10/2020 to 30/11/2020

Source: the authors.

Statistical Analysis

The dependent variables were described in numbers relative to the total population of the respective locality, from the following formulas:

$$TI = \frac{\text{Total Covid-19 cases reported per twin city and period}}{\text{Total population of the relevant city, year 2020}} \times 100{,}000$$

$$TM = \frac{\text{Total deaths from Covid-19 reported per twin city in the period}}{\text{Total population of the relevant city, year 2020}} \times 100{,}000$$

Both incidence rates and Covid-19 mortality rates were calculated for each of the two observations (before and after).

The Shapiro-Wilk test was applied to verify normality in data distribution. Given the non-parametric distribution of the data, the Mann-Whitney U test was used to compare the evaluated groups and the Wilcoxon test was used to test the association between border openness and Covid-19 incidence and mortality rates in Brazilian twin cities.

To verify the factors associated with the increase of Covid-19 cases in Brazilian twin cities during the period of reopening of international land borders we conducted a case-control study. All Brazilian twin cities were included and characterized as cases or controls. The cases were defined as the twin cities that had an increase in the Covid-19 incidence rate during the period studied, regardless of whether or not the international land border was opened, while controls were obtained from those twin cities in which the Covid-19 incidence rate did not increase during the study period.

The dependent variable was the increase in the incidence rate after the opening of the land borders. The independent variables were selected taking into account the socio-demographic reality of the cities studied, the following independent variables were determined:

- Population: ordinal variable
    - Small: population less than or equal to 10,000 inhabitants;
    - Medium: population between 10,001 and 50,000 inhabitants;
    - Large: population greater than or equal to 50,001 inhabitants.
- Airport: nominal variable
    - Yes: twin cities that have an airport;
    - No: twin cities without an airport;
- Distance: nominal variable
    - Conurbed cities;
    - Non-conurbed cities.
- Type of border: nominal variable.
    - River with bridge;
    - River without bridge;
    - Dry border.

The data for the population variable was taken from the IBGE, while the data for the other variables was collected from Google Maps. Microsoft Excel 2019 and IBM SPSS Statistics version 25.0 were used for the statistical procedures.

Descriptive analysis and Pearson's Chi-square test were carried out for cases and controls. The variables were described according to their relative frequency. Fisher's exact test was applied to verify the factors associated with an increase in the incidence rate.

RESULTS

Results from the controlled before-after study

Thirty-three twin cities were analyzed, 19 (57.6%) in the intervention group and 14 cities (42.4%) in the control group. Thirteen (39.4%) twin cities had dry borders, 15 (45.6%) had river borders with road access by bridge, and 5 (15.0%) had river borders without road access by bridge. The twin cities with the largest populations were: Foz do Iguaçu (258,248 inhabitants), Uruguaiana (126,866 inhabitants), and Corumbá (112,058 inhabitants) (Table 1).

Table 1 – Twin City Characteristics

	City	Population	Border Type	Border country
Intervention group	Aceguá	4,942	Dry Border	Uruguay
	Barra do Quarai	4,227	River with bridge	Uruguay
	Bela Vista	24,735	River with bridge	Paraguay
	Brasileia	26,702	River with bridge	Bolivia
	Caceres	94,861	Dry Border	Bolivia
	Chuí	6,770	Dry Border	Uruguay
	Coronel Sapucaia	15,352	Dry Border	Paraguay
	Corumbá	112,058	River with bridge	Bolivia
	Epitaciolândia	18,696	River with bridge	Bolivia
	Foz do Iguaçu	258,248	River with bridge	Paraguay
	Guaira	33,310	River with bridge	Paraguay
	Guajará-mirim	46,556	Fluvial without bridge	Bolivia
	Jaguarão	26,500	River with bridge	Uruguay
	Mundo Novo	18,473	River with bridge	Paraguay
	Paranhos	14,404	Dry Border	Paraguay
	Ponta Porã	93,937	Dry Border	Paraguay
	Porto Murtinho	17,298	Fluvial without bridge	Paraguay
	Quarai	22,607	River with bridge	Uruguay
	Santana do Livramento	76,321	Dry Border	Uruguay
Control Group	Assis Brazil	7,534	River with bridge	Peru
	Barracão	10,312	Dry Border	Argentina
	Bonfim	12,557	River with bridge	Guyana
	Dionisio Cerqueira	15,545	Dry Border	Argentina
	Itaqui	37,489	Fluvial without bridge	Argentina
	Oiapoque	27,906	River with bridge	French Guyana
	Pacaraima	18,913	Dry Border	Venezuela
	Porto Mauá	2,352	Fluvial without bridge	Argentina
	Porto Xavier	10,194	Fluvial without bridge	Argentina
	Santa Rosa do Purus	6,717	Dry Border	Peru
	Santo Antônio do Sudoeste	20,261	Dry Border	Argentina
	São Borja	60,019	River with bridge	Argentina
	Tabatinga	67,182	Dry Border	Colombia
	Uruguaiana	126,866	River with bridge	Argentina

Source: the authors.

The Covid-19 incidence and mortality rates increased in both groups. Interestingly, while most (57.1%) of the cities in the control group did not show an increase in the Covid-19 incidence rate, the same was observed in 63.1% of the cities in the intervention group. Regarding mortality rate, the proportion of

municipalities that presented increased values was also higher in the control group (46.1% vs 31.6%) (Table 2).

Table 2 – Covid-19 incidence rate and death rate, Twin City, Brazil

	City	Incidence rate per 100,000 inhabitants		Mortality rate per 100,000 inhabitants	
		Before	After	Before	After
Intervention group	Aceguá	0	60.23	0	0
	Barra do Quarai	731.48	353.94	0	0
	Bela Vista	148.94	92.59	8.05	0
	Brasileia	123.59	33.71	22.47	0
	Caceres	683.88	1432.78	33.56	25.2
	Chuí	146.37	87.82	0	0
	Coronel Sapucaia	394.85	485.47	6.47	6.47
	Corumbá	994.06	615.08	26.63	16.86
	Epitaciolândia	476.04	155.11	21.39	5.35
	Foz do Iguaçu	947.78	1827.72	16.28	21.3
	Guaira	110.46	519.45	5,97	2,99
	Guajara-Mirim	1065.42	230.13	34.09	6.39
	Jaguarão	246.89	231.70	11.40	0
	Mundo Novo	129.19	409.09	0	5.38
	Paranhos	212.68	34.30	6.86	0
	Ponta Porã	440.62	329.42	13.64	15.74
	Porto Murtinho	148.91	784.65	0	28.64
	Quarai	44.38	39.94	0	4.44
	Santana do Livramento	283.07	118.28	0	1.33
Control Group	Assis Brazil	2222.51	1163.55	39.22	0
	Barracão	415.58	144.97	0	0
	Bonfim	346.43	2676.95	15.75	7.87
	Dionisio Cerqueira	192.41	70.55	6.41	6.41
	Itaqui	615.58	460.35	8.03	8.03
	Oiapoque	315.41	126.17	7.01	10.51
	Pacaraima	974.74	417.74	19.89	4.97
	Porto Mauá	85.76	214.41	0	42.88
	Porto Xavier	709.78	906.94	0	19.72
	Santa Rosa do Purus	1320.18	464.24	0	0
	Santo Antônio do Sudoeste	171.96	206.35	0	0
	São Borja	532.06	565.52	11.71	25.10
	Tabatinga	127.00	52.55	2.92	4.38
	Uruguaiana	330.53	371.55	6.31	7.89

Source: the authors

Table 3 – Incidence rate comparison, intergroup and before-and-after. Twin City, Brazil

	Initial observation Median (IQR)	Final observation Median (IQR)	Z-score[1]	p-value
Control group	381.00 (261.31 – 932.96)	394.64 (163.23 -957.03)	1.09	0.27
Intervention group	246.89 (222.17 – 549.26)	231.70 (179.15 – 646.26)	0.20	0.84
U score[2]	101,000	110,000		
p-value	0.24	0.40		

[1] Wilcoxon test. [2] Mann-Whitney test.
Source: the authors.

Table 4 – Mortality rate comparison, intergroup and before-and-after, Twin City. Brazil

	Initial observation Median (IQR)	Final observation Median (IQR)	Z-score	p-value
Control Group	6.36 (2.09 -14.66)	7.14 (2.88-16.79)	0.53	0.59
Intervention group	6.86 (5.23 -16.54)	4.44 (2,86 – 11.88)	1.53	0.12
U-score	118,500	112,000		
p-value	0.59	0.44		

Source: the authors
[1] Wilcoxon test. [2] Mann-Whitney test.

The Mann-Whitney test showed that the control and intervention groups had comparable incidence rates of Covid-19 at both the initial (U = 101,000, p = 0.24) and final observation (U = 110,000, p = 0.40). The same was observed for the mortality rate at baseline (U = 118,500, p = 0.59) and final observation (U = 112,000, p =0.44, respectively) (Table 3).

Furthermore, the before-and-after Covid-19 incidence rate statistics did not change significantly in either the control group (381.00 [261.31 - 932.96] vs 394.64 [163.23 – 957.03] per 100,000 population, z = 1.09, p = 0.27) or the intervention group (246.89 [222.17 – 549.26] vs 231.70 [179.15 – 646.26] per 100,000 population, z = 0.20, p = 0.84). The same occurred when analyzing the Covid-19 mortality rate; no statistically significant variation was observed in either the control group (6.26 [2.09- 14.66] per 100,000 population vs 7.14 [2.88 – 16.79] per 100,000 population, z = 0.53, p = 0.59) or the intervention group (6.86 [5.23-16.54] per 100,000 population vs 4.43 [2.86 -11.88] per 100,000 population, z = 1.53, p = 0.12) (Table 4).

Results from the case-control study

Thirteen (39.4%) twin cities showed an increase in the Covid-19 incidence rate and made up the cases (Aceguá, Cáceres, Coronel Sapucaia, Foz do Iguaçu, Guairá, Mundo Novo, Porto Murtinho, Bonfim, Porto Mauá, Porto Xavier, Santo Antônio do Sudoeste, São Borja e UruAb).

At the same time, 20 (60.6%) Brazilian twin cities did not show an increase in the incidence rate and made up the control group (Barra do Quarai, Bela Vista, Brasileia, Chui, Corumba, Epitaciolândia, Guajara-Mirim, Jaguarão, Paranhos, Ponta Porã, Quarai, Santana do Livramento, Assis Brasil, Barracão, Dionisio Cerqueira, Itaqui, Oiapoque, Pacaraima, Santa Rosa do Purus, Tabatinga).

The most frequent category of each variable was similar between cases and controls; cases and controls were characterized, respectively, as medium-sized cities (53.8% vs 70%); with no airport (76.9% vs 80%), were not-conurbed (92.3% vs 75%) and had dry border (38.5% vs 50%). Fisher's exact test showed that population size (x2(2) = 0.88; p = 0.67), the presence of airports in twin cities (x2(1) = 0.45; p = 1.00), the distance between twin cities and neighboring foreign cities (x2(1) = 1.58; p = 0.21), and

the type of border (x2(2) =1.12 p = 0.57) were not associated with the Covid-19 incidence rate (Table 5).

Table 5 – Absolute and relative frequency of demographic variables in Brazilian twin cities according to cases and controls and Fisher's exact test, 2020

	Number of twin cities				
Variable	**Cases**	**(%)**	**Controles**	**(%)**	**p*value**
Total	**13**	**100**	**20**	**100**	**-**
Population					**0.67**
Large	3	23.1	3	15.0	-
Medium	7	53.8	14	70.0	-
Small	3	23.1	3	15.0	-
Airport					**0.58**
No	10	76.9	16	80.0	-
Yes	3	23.1	4	20.0	-
Distance					**0.21**
Conurbated	1	7.7	5	25.0	-
No conurbated	12	92.3	15	75.0	**-**
Type of border					**0.64**
River with bridge	5	38.5	8	40.0	-
River without bridge	3	23.1	2	10.0	-
Dry border	5	38.5	10	50.0	-

Source: the authors.

DISCUSSION

In this comprehensive survey we initially examined all Brazilian twin cities to assess the effect of opening international land border on Covid-19 incidence and mortality rates. Afterwards, we investigated the association between population size, presence of airport, distance between twin cities and type of border and incidence of Covid-19. Contrary to expectations, border closure did not significantly affect Covid-19 incidence and mortality rates, nor was it associated with the evaluated characteristics. These findings support the argument that border restrictions, often implemented during outbreaks, are an ineffective means of controlling pandemics (RUSSELL et al., 2021; PEGO et al., 2021).

The absence of association between the closure of international land borders and the impact of a communicable disease is particularly relevant to understand the extent of the damage resulting from the restriction to the flow of people on the existing daily interactions in twin cities, which are not restricted to economic and customs aspects, but extend to interpersonal, labor, emotional, and social protection relationships (MAGALHÃES, RONCONI, ASSIS, 2021; PEGO et al., 2021; NOGUEIRA; DA CUNHA, 2020).

In Brazil, the first case of Covid-19 in a border city occurred in March, possibly due to the entry and spread of Sars-COV-2 via airports, a facility that is scarce in Brazilian twin cities and their international counterparts (PEGO et al, 2020; SALAS, 2001). This scarcity of airports mimics a closure of air borders, which confirms the idea that early restrictions on the international flow of people can delay the spread of the virus for a few days or weeks (BIER, 2020).

In the broader scenario, Brazil stood out in Latin America as the epicenter of the Covid-19 pandemic in 2020 (THE LANCET, 2020), which may have been influenced by how the restriction of international movement of people was implemented. The first land border closed by the Brazilian government was with Venezuela on March 18, 2020 followed by the other borders two days later (MONTEIRO; DA SILVA;

RIBEIRO, 2020). On March 23, 2020 Brazil partially closed the entry of foreigners by air. The only partial closure of air traffic may have hindered the effectiveness, albeit temporary, of measures restricting the movement of people, meaning that, at the time of the survey, the Covid-19 incidence rate was already high (RUSSELL, 2021). Numerous factors could potentially impact the transmission of Sars-COV-2, particularly in border regions, where biogeographical, geographical, and socioeconomic factors play crucial roles in shaping the disease dynamics (COELHO et al., 2020). It is widely acknowledged that the size of a city's population can influence the epidemiological trajectory, potentially leading to a more rapid spread of Sars-COV-2 in densely populated areas characterized by heightened commercial activity and human mobility). Indeed, the increased spread of the virus in cities with larger populations has been attributed to the interaction of trade and constant human flow, complicating efforts to control outbreaks in these areas (COELHO et al., 2020)

The flow of people across borders in twin cities is influenced by various factors, primarily the distance between the cities in neighboring countries and the type of border. These are crucial aspects affecting the spread of Covid-19, as they define the geographical space where the disease proliferates following the movement of hosts (COELHO et al., 2020). Given the virus's high transmissibility, it's essential to recognize that the issue extends beyond mere overcrowding in fixed spaces; there's also concern about the potential trail of contamination individuals leave as they move through different areas (AGUIAR, 2020).

Given these considerations, one might anticipate a notable surge in Covid-19 incidence in twin cities, particularly those situated along dry borders, where ongoing interactions between neighboring cities are frequent and border controls may be intricate and imperfect. However, our investigation revealed no discernible association between population size, the presence of airports, distance between cities, border type, and the incidence of Covid-19, which we hypothesize is due to spread of Covid-19 within the country and between countries via air traffic, which are not affected by international land borders closure.

A limitation of this research was the fact that the twin cities of neighboring countries were not included in the study due to lack of reliable publicly available data at the time of the study. However, our research is relevant for several aspects. Brazil is the largest in South America, both in territory and population. It is also the country with the most land borders in the American continent and among developing countries. Additionally, the data were collected prospectively by the Ministry of Health, thus, considering them centralized and official data, which allows their characterization as quality data. Furthermore, during the research period, the Covid-19 vaccine was still under development, so discrepancies in the immunization rate between countries, or even low vaccine availability in more distant borders, were not a factor influencing the research results.

Finally, our research will provide input for decision making regarding the closure of land borders in the occurrence of communicable disease outbreaks. For example, given the lack of association between the closure of international land borders and an increase in the incidence of a communicable disease, policy makers may be inclined to a less conservative attitude when discussing the closure of international land borders, particularly regarding the duration of such a restriction.

CONCLUSION

Reopening international land borders after long periods of closure in regions with limited international flow of people by air transportation does not affect the spread of the disease, suggesting limited effectiveness of such intervention in controlling international transmission of airborne diseases. This should be taken into account when governments discuss interventions against the international spread of communicable diseases. Further research should also explore the factors contributing to the spread of Sars-COV-2 in twin cities within a shorter time frame following border closure. This would allow for a more comprehensive assessment of the effectiveness of border closure measures over time.

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