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Abstract: The objective of this study was to analyze the effect of the COVID-19 pandemic on suicide rates among Brazilian residents, stratified by sex. This study evaluated the behavior of monthly suicide rates based on an interrupted time series analysis of the months preceding (from January 2017 to February 2020) and following (from March 2020 to December 2022) the first diagnosed case of Covid-19 in Brazil. We used an interrupted time series model (quasi-Poisson), accounting for the presence of serial autocorrelation in the residuals and seasonality.Among men, we identified an abrupt decrease (RR<1, p<0.05) in monthly suicide rates at the onset of the pandemic, followed by a progressive increase (RR>1, p<0.05). An exception to this trend occurred in the Northeast region and among elderly men, where there was an abrupt increase in suicide rates at the start of the pandemic. For women, a reduction in monthly suicide rates was observed during the early stages of the pandemic only in the Central-West and Northeast regions, as well as in the 20-39 age group.The pandemic's effect was not uniform across Brazilian men and women, according to stratification variables; however, we observed a progressive upward trend over the course of the pandemic.

Keywords: Suicide; COVID-19; health inequities

1. Introduction

Suicide is a complex, multifactorial social phenomenon and is considered a serious global public health issue. Worldwide, approximately 700,000 people die due to this cause annually. Contrary to the trend observed in most regions of the world, this condition continues to rise in the Americas and in Brazil [1]. According to the Brazilian Ministry of Health, the national suicide rate is 7.5 deaths per 100,000 inhabitants [2], a rate deemed low by the World Health Organization when compared to those in European, North American, and Asian countries, where rates may exceed 15 deaths per 100,000 inhabitants [1]. However, when assessing the absolute number of suicides in Brazil, the country ranks among the top ten nations with the most reported suicides [1-2]. Given the country's continental dimensions, there are significant regional disparities in these rates, with specific areas, such as the southern region, recording suicide rates exceeding 11.0 per 100,000 inhabitants in 2021 [2].

Suicidal behavior is associated with risk factors at both individual and situational levels, which interact to heighten the risk of this health condition. These factors include mental disorders, existential philosophical dilemmas, sociocultural motivations, a history of violence, complicated grief, and a history of suicide attempts, among others. The mental disorders most strongly linked to suicide are depression, bipolar affective disorder, schizophrenia, and the abusive use of alcohol and

psychoactive substances. At the situational level, key factors include inequities in access to employment and income, difficulties in accessing healthcare services, economic crises, health crises, and natural disasters, as well as the availability of highly lethal means such as firearms and highly toxic pesticides and insecticides [3-10].

The emergence of the Covid-19 pandemic led some authors to predict an increase in the number of self-harm incidents, suicide attempts, and suicides during the pandemic months [8,10-12]. The preventive measures implemented at the onset of the pandemic included stay-at-home orders (lockdowns), the closure of schools, universities, and businesses, in addition to the reconfiguration of healthcare services. Although these measures were effective in reducing the transmission of the disease, they also triggered an economic crisis and exacerbated the psychosocial problems within the population [13]. Consequently, this worsened pre-existing conditions and increased the prevalence of mental health issues, particularly among vulnerable populations [14-18].

It is important to note that the pandemic's impact on suicide rates was not uniform across all countries. The particular socio-economic and cultural characteristics of each region, combined with individual-level factors, played a major role in shaping the pandemic's influence on suicidality [14-18]. In this context, studies have shown a reduction or stabilization of suicides in high-income countries that were quick to implement financial support measures for the population during quarantine [19-23]. Notably, among these countries are Germany, Australia, Canada, England, South Korea, Japan, Norway, and Taiwan [19-23]. Conversely, in countries such as Nepal and Brazil, there was an increase in suicides during the initial months of the pandemic [24-25]. Moreover, evidence shows that after public health crises, natural disasters, terrorist attacks, and wars, suicide rates often increase over time [11,22,26-29].

The initial decrease in suicides documented following such emergencies is attributed to a temporary surge in social cohesion and solidarity within affected societies, which serves as a protective factor against suicide. However, as time progresses, this increased social cohesion tends to erode, and suicide rates subsequently rise [11,26-29].

The impact of the pandemic on suicides showed variations according to sex, age group, ethnicity, and country of residence [19-25,30-35]. In Brazil, despite its high gross domestic product and a universal healthcare system, socioeconomic and health inequities remain prominent. These inequities worsened during the pandemic, driven by the denialist stance of the former government [36-38]. Such positions contributed to high mortality rates from Covid-19, significant unemployment rates, and an increase in food insecurity, as well as mental health issues such as stress, anxiety, and depression [36-38].

Studies conducted in Brazil using suicide records from 2020 and early 2021 have shown divergent results. While Orellana & De Souza (2022) [34] and Soares et al. (2022) [39] reported a reduction in the number of suicides during the initial months of the pandemic, a contrasting study by Ornell et al. (2022) [26] identified an increase in suicide-related excess deaths during 2020, particularly in the Midwest, Northeast, and Southeast regions.

Further supporting the conclusions of the Ornell et al. study, Orellana & De Souza (2022) also reported a rise in suicides, observing differences based on sex, age, and place of residence. Among their findings, notable increases were identified in specific demographic groups: a 26% increase in suicides among men aged 60 and older in the Northern region and a 40% increase among women of the same age group in the Northeast region [34].This heterogeneity in findings may reflect variations in the methodologies employed by the studies and the limited number of pandemic months analyzed [26,34,39].

Thus, the present study seeks to broaden the understanding of the pandemic's impact on suicide rates in Brazil. The analysis will be stratified by sex, age group, geographic region, method of suicide, and race/skin color, covering the entire pandemic period (March 2020 to December 2022). The research questions guiding this study are as follows: Did the Covid-19 pandemic have differential effects on suicide rates among men and women in Brazil, depending on age group, geographic region, race/skin color, and method?

We opted to conduct stratified analyses by sex, as men and women tend to engage in self-destructive behaviors aligned with societal gender roles. These behaviors are shaped by hegemonic masculinities and femininities, contributing to what is commonly referred to as the suicide or gender paradox [40-42]. Specifically, these behaviors often involve the use of different methods of suicide, which vary in lethality, accessibility, and cultural acceptance [40-48]. Men's suicide attempts typically involve more lethal and aggressive means, such as hanging or firearms, whereas women more frequently attempt suicide by self-intoxication. This disparity leads to a higher likelihood of men dying by suicide, while women exhibit higher rates of suicidal ideation and suicide attempts, thereby being more broadly affected by suicidal behaviors [40-48].

Given this context, the general aim of this study is to analyze the effect of the Covid-19 pandemic on suicide rates in Brazilian residents, stratified by sex, region, age group, race/skin color, and method, over the period from January 2017 through December 2022, using interrupted time series analysis.

2. Materials and Methods

2.1. Study Design and Location

This interrupted time series (ITS) ecological study was conducted in accordance with the Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER) statement [49]. The objective was to evaluate the behavior of monthly suicide rates in Brazil, based on a time series spanning 72 months —of which 38 months were prior to the first confirmed Covid-19 case (January 2017 to February 2020), and 34 months occurred after the first Covid-19 diagnosis in the country (March 2020 to December 2022). The first confirmed case of Covid-19 in Brazil was reported on February 26, 2020.

Brazil is divided into five major geographical regions: North, Northeast, Southeast, South, and Midwest. The population of Brazil was estimated at 207.8 million inhabitants in 2022. The Southeast region has the largest population, followed by the Northeast, while the North and Midwest. have the smallest populations. The highest Human Development Index (HDI) values are observed in the South, while the lowest are concentrated in the Northeast and North regions. The North is characterized by low population density and a vast geographic area that includes much of the Amazon rainforest. The Southeast region stands out for its dynamic labor market, while the Midwest, which houses the nation's capital, is primarily driven by agriculture and livestock farming [50].

2.2. Data Source

2.3. Data Analysis

The data on suicide were extracted from the Mortality Information System (SIM), considering the records of deaths from external causes made available by the Informatics Department of the Brazilian Unified Health System (SUS) [51]. In accordance with the 10th International Statistical Classification of Diseases and Related Health Problems (ICD-10), the codes used were X60-X84 (total of intentional self-inflicted injuries). Following the methodology adopted by the Ministry of Health, suicide was defined as the sum of death records classified as X60 to X84 and Y87.0 (sequelae of intentional self-inflicted injury) [2].

The population data were obtained from the SUS Informatics System (DataSUS), based on national censuses conducted in 1980, 1991, 2000, 2010, and 2022. For the years in-between, we relied on intercensal projections for July 1st, as estimated by IBGE [50]. Additionally, we utilized population estimates by race/skin color provided by the Economic Research Institute (IPEA), particularly from their publication "The Portrait of Gender and Race Inequalities." Importantly, race/skin color data disaggregated by sex were only available for three categories: white, black, and brown [52].

Since suicidal behavior has been widely demonstrated to differ between men and women [11, 22,32,40-42, 45-48], and given that these differences often exacerbate during crises, we stratified all analyses by sex. Furthermore, we selected variables such as age group (divided into 10-14, 15-19, 20-

39, 40-59, and 60 years or older), macro-region (North, Northeast, Midwest, Southeast, and South), and race/skin color (white and black). In terms of method, we focused on the most common approaches used in Brazil: self-inflicted poisoning (X60-X69), hanging, strangulation, and suffocation (X70), and deaths by firearm (X72-X74) [2].

The choice to start the analysis with the 10 to 14-year age group wasn't arbitrary. It was based on the observation that suicides are extremely rare in younger age groups and that deaths under 10 years old may reflect instances where children did not fully comprehend the irreversible nature of death [2, 25, 31-34]. Finally, concerning race/skin color, when referring to the black population — in alignment with the Brazilian Institute of Geography and Statistics (IBGE) — we considered this group to include all individuals self-identified as either black or brown [52], as per Brazil's classification of African descendants.

2.3.1. Exploratory Analysis

We calculated annual and monthly age-specific suicide rates by sex and standardized these rates using the direct method, adopting the world population proposed by the World Health Organization as the standard [53]. Following this, we estimated standardized annual mean mortality rates for each year and the overall period (2017 to 2022), stratified by geographic region and sex.

For the other variables, we calculated standardized mean monthly rates , dividing the data into the pre-pandemic (January 2017 to March 2020) and pandemic periods (March 2020 to December 2022), and further stratifying by age group, region, method of suicide, and race/skin color. After estimating these rates, we calculated the mean monthly rates and standard deviations for the entire period, as well as for the periods before (January 2017 to February 2020) and during the Covid-19 pandemic (March 2020 to December 2022). To compare the differences across age groups, region, method of suicide, and race/skin color, we employed Welch's test and ANOVA, both of which were appropriate based on results from the Shapiro-Wilk and Kolmogorov-Smirnov tests indicating normal distribution. In cases where ANOVA results were statistically significant, post-hoc comparisons were made using Tukey's test.

Given the nature of our dataset, where we had 38 months pre-pandemic (January 2017 to February 2020) and 34 months during the pandemic (March 2020 to December 2022), the Welch test (a t-test adaptation for unequal sample sizes) was particularly apropos. In all analyses, p-values less than 0.05 were considered statistically significant [54].

Additionally, to explore the temporal evolution of standardized monthly suicide rates by sex and stratified variables, we generated line graphs and applied LOESS (Locally Estimated Scatterplot Smoothing) to smooth the trends [55].

2.4. An Analysis of the Impact of the Pandemic on Suicides in Brazil Using Interrupted Time Series

In analyzing the effect of the pandemic on suicides, we chose to use Interrupted Time Series (ITS) because this method has been widely employed in the literature as a tool for evaluating the impact of public policies and significant historical events on health outcomes [56-63].

This method involves algebraic segmentation of the time series, incorporating changes in both level and trend [56,62-63]. The level refers to the initial value of the series in each segment, while the trend represents the change in values over the period covered by that segment. This approach allows the analysis of whether the intervention caused an immediate effect (level change) and/or a progressive impact (trend change) on the outcome under study.

Suicide mortality rates were analyzed through the adjustment of a segmented regression model, with the number of suicides as the response variable and all months from 2017 to 2022 as the independent variables (ranging from 1 to 72 months). To examine the level change, the "pre-pandemic" period was coded as 0, and the "during pandemic" period was assigned a value of 1 [56,62-63].

A quasi-Poisson regression model was employed, as it allows for the adjustment of data to ensure that the variance is proportional to the mean, thereby correcting overdispersion, which is commonly found in count data. The level and trend change model (level and slope change) was

utilized to simultaneously analyze the abrupt change in level and the gradual shift in the trend of monthly suicide rates after the onset of the Covid-19 pandemic, according to the following mathematical notation [56,63].

$$Yt \sim \text{Quasi-Poisson}(\mu t)$$

$$\log(\mu_t) = \beta_0 + \beta_1 T + \beta_2 X t + \beta_3 (T-T0) X_t + \text{offset} (\log(Pop_t))(I)$$

Where Y_t represents the observed count of suicides at time t, and μt is the expected mean of suicides at time t. T represents the time in months since the beginning of the study period, while X_t refers to the intervention (the pandemic), modeled as a dummy variable: t=0 for the pre-pandemic period and t=1 for the period during the pandemic, beginning at the 39th month (March 2020). β_0 represents the baseline level at T=0; β_1 captures the trend in suicide counts associated with the passage of time (the counterfactual trend). β_2 relates to the change in the baseline level, i.e., the expected mean level of suicides post-pandemic, while β_3 quantifies the change in slope following the onset of the pandemic (with T0 marking the pandemic onset). Lastly, $\log(Pop_t)$ serves as an offset term that adjusts the expected mean of suicides based on population size [56,63].

In the construction of the models, the length of the month and seasonal effects were considered, using Fourier terms (in this case, two pairs of sine and cosine functions) and a duration of 12 months [55-56,60,63]. The presence of autocorrelation in the residuals was analyzed using the Durbin-Watson test and its critical values, along with sample autocorrelation and partial autocorrelation function plots (ACF and PACF) [55-56,60,63-64]. In the presence of serial autocorrelation, models were estimated with the inclusion of n lags, which were implied by the autoregressive process [55-56,60-63]. The selection of the best-fitting model took into consideration the criteria of parsimony and model fit quality, as measured by the Akaike Information Criterion (AIC)—where the lower the AIC value, the better the fit [56,63].

The analyses were conducted using the lmtest , Epi , tsModel , gls , splines , vcd , ggplot2 , and tidyverse libraries in R version 4.4.1 [65]. A significance level of $p<0.05$ was considered statistically significant. The results were presented with their respective relative risk (RR) values and 95% confidence intervals (CI 95%), obtained by exponentiating the parameters of the quasi-Poisson model [56,60-63].
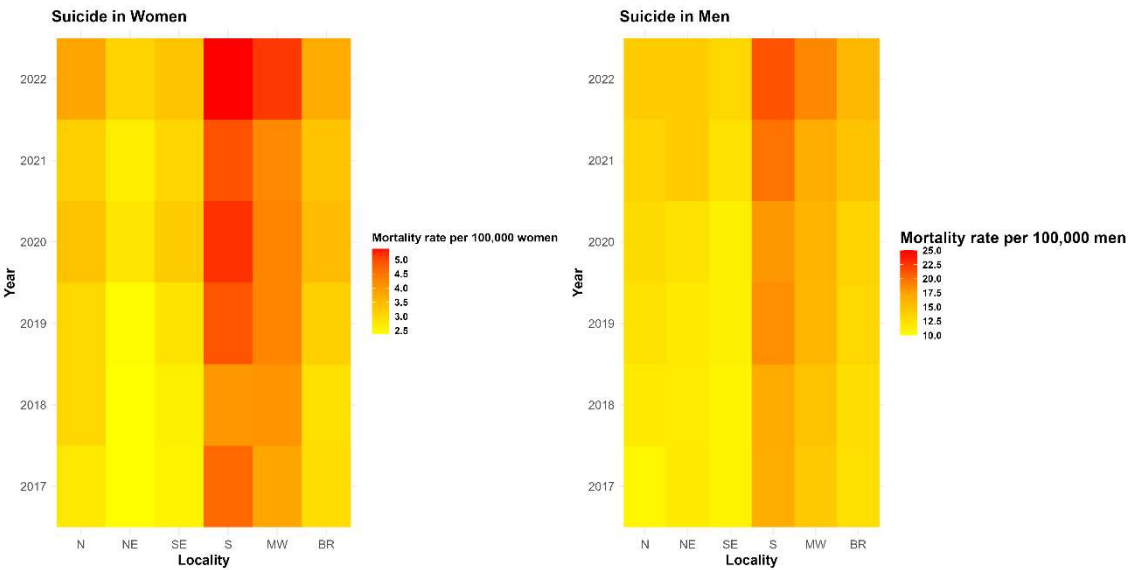
2.6. Ethical Aspects

The research was conducted using freely available data from SIM/DATASUS, where no identification of individual subjects occurs, and therefore there was no need to submit the study to a Research Ethics Committee, in accordance with Article 1 of CNS Resolution No. 510, dated April 7, 2016 [66].

3. Results

3.1. Descriptive Analysis

In Brazil, during the period from January 2017 to December 2022, a total of 85,004 suicides were recorded, encompassing individuals between the ages of 10 and 14 up to 80 years and older. Of these, 78.38% were men (n=66,622) and 21.62% were women (n=18,382). The age-standardized annual suicide rate for men was 3.84 times higher than that observed among women (12.60 suicides per 100,000 men vs. 3.28 suicides per 100,000 women). Across both sexes and in all regions, a progressive increase in mortality rates was observed throughout the study period, with the highest rates recorded in the final year of the pandemic (2022) (Figure 1).

Note: N=North, NE= Northeast, SE= Southeast, S= South, MW= Midwest, BR= Brazil.

Figure 1. Standardized annual suicide rates per 100,000, by year and sex, Brazil, 2022. Source: Mortality Information System (SIM/SUS) | National Bureau of Statistics (IBGE).

Among men, the highest standardized annual average suicide rates were observed in the South and Central-West regions, while the lowest rates were recorded in the Southeast and Northeast regions (Figure 1). Specifically, the suicide rate for males in the South and Central-West regions amounted to 18.58 and 14.78 suicides per 100,000 men, respectively. In contrast, the corresponding rates in the Southeast and Northeast regions were 10.72 and 11.36 suicides per 100,000 men, respectively. A similar pattern was observed among women: the standardized suicide rate in the South and Central-West regions was 4.93 and 4.34 suicides per 100,000 women, respectively. In the Southeast, the standardized suicide rate for women exceeded that of the Northeast, with rates of 2.95 vs. 2.65 suicides per 100,000 women.

This trend was maintained when evaluating the standardized monthly average rates throughout the study period. The differences were statistically significant at the 5% level, according to the ANOVA test, and were further confirmed by Tukey's post hoc test. Exceptions were noted in the comparison of the standardized monthly average suicide rates among males between the South and Central-West regions (p=0.53), between Brazil and the Northeast (p=0.47), and between the Southeast and Brazil (p=0.08). Regarding the standardized monthly average rates for women, Tukey's test did not identify any statistically significant differences between the rates of the Southeast when compared to Brazil (p=0.10), the North and Brazil (p=0.99), the Southeast and Northeast (p=0.12), and the Southeast and North (p=0.32).

Among men, there was a positive gradient in the average monthly suicide rates with increasing age, ranging from 0.098 (SD=0.039) among adolescents aged 10 to 14 years to 1.302 (SD=0.131) among the elderly (Figure 2 and Table 1). These differences were statistically significant, according to the ANOVA test (p<0.001) and were validated through Tukey's post hoc test (p<0.05) when comparing all categories.

Regarding women, we observed lower average monthly rates in the 10-14 age group, with higher rates recorded among adolescents (15-19 years) and middle-aged women (40-59 years). These rates ranged from 0.109 (SD=0.042) to 0.313 (SD=0.074) (Figure 3 and Table 1). The differences in suicide rates by age group among women were statistically significant based on the ANOVA test (p<0.001) and were confirmed by Tukey's post hoc test—except for the comparison between the average monthly rates of the 15-19 and 40-59 age groups (p=0.99).
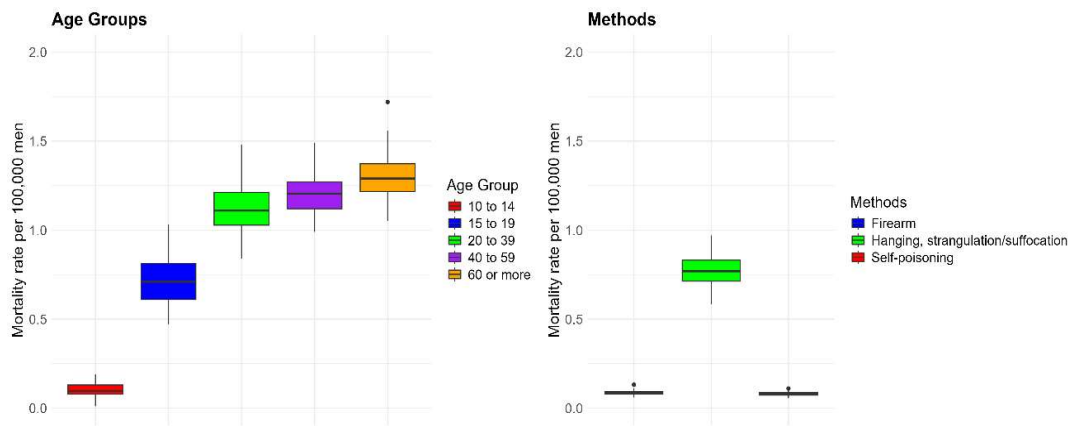
Figure 2. Standardized Monthly Suicide Rates per 100,000 Men, by Age Group and Method, Brazil, 2024. Source: Mortality Information System (SIM/SUS) | National Bureau of Statistics (IBGE).

Figure 3. Standardized Monthly Suicide Rates per 100,000 Women, by Age Group and Method, Brazil, 2024. Source: Mortality Information System (SIM/SUS) | National Bureau of Statistics (IBGE).
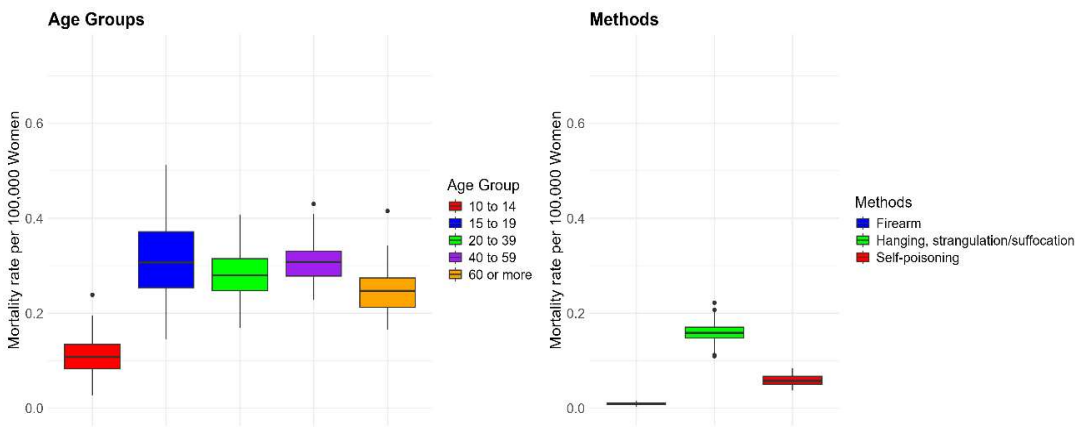
When evaluating the monthly average suicide rates by race/skin color from 2017 to 2022, we observed higher suicide rates in white men and women [(1.000 (SD=0.097) vs. 0.288 (SD=0.036)], compared to Black men and women [(p<0.001; 0.795 (SD=0.108) vs. 0.193 (SD=0.033)] (Table 1). Among both men and women, hanging, strangulation, and suffocation emerged as the most common methods of suicide. In women, autointoxication ranked as the second most frequent method, whereas firearms held this position among men (Figure 2, Figure 3). These differences were statistically significant (p<0.001), as validated by Tukey's post hoc test, except for the comparison between firearm-related suicides and autointoxication rates among men (p=0.82).

Table 1. Basic descriptive statistics on mortality rates by sex, age group, region, and race/skin color and method of perpetration. Brazil, January 2017 to December 2022, Brazil,2024.

Variable	Men		Women	
	Mean (SD)[a]	p-value	Mean (SD)[a]	p-value
Age group (age)[b]				
10 to 14	0.098 (0.039)		0.109 (0.042)	
15 to 19	0.713 (0.134)	<0.001	0.313 (0.074)	<0.001
20 to 39	1.125 (0.148)		0.282 (0.049)	
40 to 59	1.212 (0.121)		0.308 (0.041)	

60 or more	1.302 (0.131)			0.249 (0.047)	
Locality [b]					
North	1.041 (0.167)			0.266 (0.06)	
Northeast	1.048 (0.125)			0.220 (0.039)	
Southeast	0.967 (0.112)	<0.001		0.245 (0.037)	<0.001
South	1.811 (0.227)			0.403 (0.083)	
Midwest	1.346 (0.194)			0.360 (0.080)	
Brazil	1.049 (0.111)			0.273 (0.034)	
Race/skin color[c]					
Black	0.795 (0.108)	<0.001		0.193 (0.033)	<0.001
White	1.000 (0.097)			0.288 (0.036)	
Method of perpetration [b]					
Firearm	0.085 (0.011)			0.008 (0.003)	
Autointoxication	0.080 (0.012)	<0.001		0.058 (0.011)	<0.001
Hanging, strangulation and suffocation	0.777 (0.092)			0.1587 (0.022)	

[a]Standard Desviation; [b]ANOVA test e [c]Welch Test. **Source:** Mortality Information System (SIM/SUS) | National Bureau of Statistics (IBGE).

3.2. Bivariate Analyses

The average monthly suicide rates, comparing the periods before and after the first COVID-19 case was diagnosed in Brazil, reveal systematically lower values in the pre-pandemic phase for most explanatory variables. These differences were statistically significant for every category. Nonetheless, exceptions were found in the 10-14 age group among women ($p = 0.144$), as well as in suicides involving firearms for both women and men ($p = 0.648$ vs. $p = 0.338$), where the observed increases were not statistically significant. A particularly marked result appeared in the 15-19 age group among men, where suicide rates fell during the pandemic compared to the preceding period ($p = 0.002$) (Table 2).

Table 2. Basic descriptive statistics on mortality rates by independent variables, before and during the Covid-19 pandemic. Brazil, January 2017 to December 2022, Brazil,2024.

Variable	Before pandemic Men Mean (SD[a])	After pandemic Men Mean (SD[a])	Men p-value[c]	Before pandemic Women Mean (SD[a])	After pandemic Women Mean (SD[a])	Women p-value[c]
Age group (age)						
10 to 14	0.092 (0.041)	0.089 (0.048)	0.144	0.097 (0.042)	0.121(0.038)	0.016
15 to 19	0.669 (0.138)	0.658 (0.179)	0.002	0.283 (0.066)	0.345 (0.070)	<0.0001
20 to 39	1.051 (0.094)	1.207 (0.154)	<0.0001	0.253 (0.035)	0.316 (0.041)	<0.0001
40 to 59	1.148 (0.091)	1.283 (0.113)	<0.0001	0.294 (0.030	0.324(0.047)	0.003
60 or more	1.255 (0.119)	1.355 (0.124)	0.001	0.242 (0.048)	0.256 (0.048)	0.217
Locality						

North	0.973 (0.154)	1.116 (0.149)	<0.0001	0.247(0.04)	0.287 (0.107)	0.011
Northeast	0.974 (0.077)	1.130 (0.118)	<0.0001	0.201(0.029)	0.241 (0.039)	<0.0001
Southeast	0.920 (0.088)	1.021 (0.113)	<0.0001	0.224(0.027)	0.269 (0.032)	<0.0001
South	1.716 (0.177)	1.918 (0.231)	<0.0001	0.381 (0.080)	0.429 (0.080)	0.014
Midwest	1.257 (0.156)	1.446 (0.185)	<0.0001	0.340(0.066)	0.382(0.089)	0.028
Brazil	0.986(0.074)	1.121 (0.104)	<0.0001	0.253 (0.020)	0.294 (0.032)	<0.0001
Race/skin color[c]						
White	0.968 (0.073)	1.037 (0.101)	0.003	0.271 (0.029)	0.310 (0.034)	<0.0001
Black	0.7215 (0.062)	0.8763 (0.090)	<0.0001	0.174 (0.022)	0.214(0.029)	<0.0001
Methods						
Firearm	0.0843 (0.011)	0.086 (0.0116)	0.338	0.009 (0.002)	0.008 (0.002)	0.648
Autointoxication	0.075 (0.009)	0.085 (0.0118)	<0.0001	0.054 (0.007)	0.064 (0.011)	<0.0001
Hanging, strangulation and suffocation	0.722 (0.061)	0.838 (0.083)	<0.0001	0.147(0.018)	0.171 (0.020)	<0.0001

[a]Standard Desviation; [b]ANOVA test e [c]Welch Test. **Source:** Mortality Information System (SIM/SUS) | National Bureau of Statistics (IBGE).

The exploratory evaluation of the time series, utilizing rates smoothed through the LOESS method, indicates a reduction in suicide rates during the early months of the pandemic (March to December 2020). This initial decline was followed by an increase in rates, varying by region and sex (Figures 4 and 5). Similar trends were observed across suicide rates stratified by age group, method of perpetration, and race/skin color (Figures S1, S2, S3, and S4).
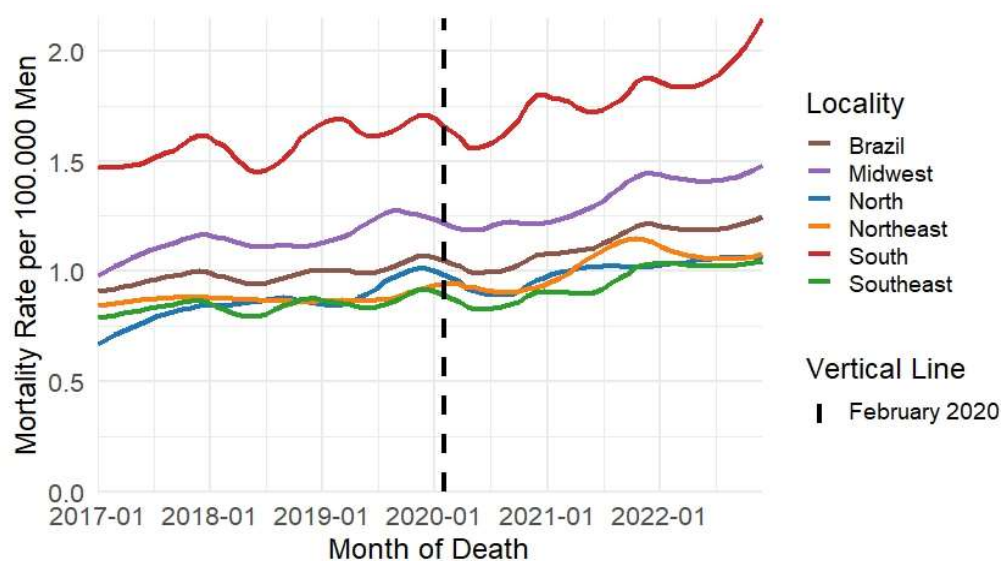
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Figure 4. Smoothed Monthly Suicide Rates per 100,000 Men using LOESS (Locally Estimated Scatterplot Smoothing), by Region, Brazil, 2024. Source: Mortality Information System (SIM/SUS) National Bureau of Statistics (IBGE).
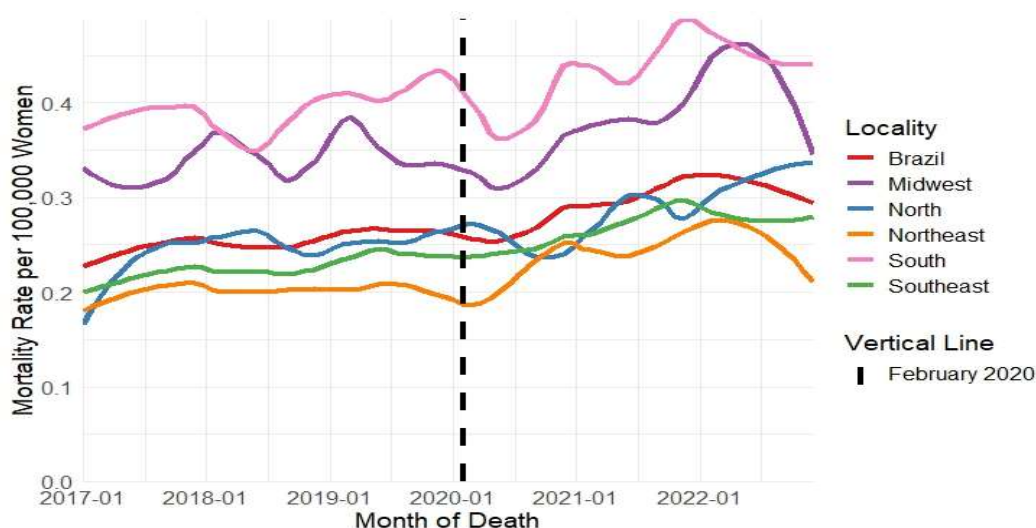

Figure 5. Smoothed Monthly Suicide Rates per 100,000 Women using LOESS (Locally Estimated Scatterplot Smoothing), by Region, Brazil, 2024. Source: Mortality Information System (SIM/SUS) | National Bureau of Statistics (IBGE).

3.3. An Analysis of the Impact of the Pandemic on Suicides in Brazil Using Interrupted Time Series

The results of the interrupted time series model stratified by age group for men revealed both a level change (an abrupt shift in average monthly suicide rates post-pandemic onset) and a trend change (long-term alterations throughout the pandemic). Among the age groups from 15-19 years to 40-59 years, there was an immediate reduction in suicide rates ($p < 0.05$) that was subsequently reversed into a progressive increase ($p < 0.05$) during the pandemic in the following age groups: 15-19 years, 20-39 years, and 40-59 years. In the 10–14-year-old age group, no significant level change was detected, but a trend shift toward a progressive increase was identified (RR = 0.939, p = 0.142; RR = 1.002, p = 0.007). Among older adults, both level and trend changes exhibited an upward shift in suicide rates (RR = 1.042, p < 0.0001; RR = 1.004, p < 0.0001) (Table 3).

For women, however, no level or trend changes were generally observed across age groups, with one exception: women aged 20-39 experienced an immediate reduction in monthly suicide rates, followed by a trend change toward a progressive increase in rates (RR = 0.945, p < 0.0001; RR = 1.105, p < 0.0001). In the 15 to 19 age group, a progressive increase in monthly rates was also observed throughout the pandemic (Table 4).

When analyzing by macro-region, we observed an initial decline in suicide rates among men nationwide and across all regions of Brazil (p < 0.05), followed by a progressive increase in rates over time (p < 0.05). The Northeast, however, deviated from this pattern, showing an abrupt increase at the onset of the pandemic (RR = 1.036, p < 0.0001) that continued to rise progressively throughout (Table 3). Among women, no immediate level changes were observed in the monthly suicide rates in Brazil, the Northeast, Southeast, or South regions. Nonetheless, a progressive upward trend was detected (RR = 1.005, p < 0.0001; RR = 1.004, p = 0.032; RR = 1.004, p = 0.0048; RR = 1.005, p < 0.0001, respectively). In the Central-West and North, there were abrupt reductions in suicide rates among women (RRMW = 0.889, p < 0.0001; RRN = 0.900, p <0.0001), followed by a progressive increase in trend (RRMW = 1.007; p < 0.0001; RRN = 1.008, p < 0.0001) (Table 4).

Regarding suicide rates by race and skin color, no level changes were observed among white women, Black men, or Black women; however, trend changes indicated an increase in suicide rates throughout the pandemic (p < 0.05). Nonetheless, among white men, both a level and trend change were detected, with an initial sharp reduction in suicide rates during the early months of the pandemic, followed by a progressive increase as the health crisis unfolded (Table 3 and Table 4).

Table 3. Effect of the Covid-19 pandemic on suicide mortality rates per 100.000 men,   Relative Risks estimated through interrupted time series analysis and by comparing the periods January 2017 to February 2020 with March 2020 to December 2022,Brazil,2024.

Variables	Categories	Interpretation	RR[a]	CI95%[b]	p-value[c]
Age group (years)	**10 to 14**				
	Level change	Not detected	0.939	0.982;1.138	0.142
	trend change	Progressive increase	1.002	1.001;1.004	0.007
	15 to 19				
	Level change	Abrupt reduction	0.864	0.832;0.899	<0.0001
	trend change	Progressive increase	1.006	1.005;1.007	<0.0001
	20 to 39				
	Level change	Abrupt reduction	0.868	0.8433;0.894	<0.0001
	trend change	Progressive increase	1.008	1.007;1.009	<0.0001
	40 to 59				
	Level change	Abrupt reduction	0.987	0.976;0.998	0.031
	trend change	Progressive increase	1.006	1.005;1.006	<0.0001
	60 or more years				
	Level change	Increase abrupta	1.042	1.027;1.057	<0.0001
	trend change	Progressive increase	1.004	1.003;1.005	<0.0001
Locality	**North**				
	Level change	Abrupt reduction	0.891	0.865 ;0.917	<0.0001
	Trend change	Progressive increase	1.009	1.008 ;1.010	<0.0001
	Northeast				

	Level change	Increase abrupta	1.036	1.012;1.061	<0.0001
	Trend change	Progressive increase	1.004	1.003;1.005	<0.0001
	Southeast				
	Level change	Abrupt reduction	0.916	0.886;0.947	<0.0001
	Trend change	Progressive increase	1.056	1.050;1.062	<0.0001
	South				
	Level change	Abrupt reduction	0.901	0.875;0.924	<0.0001
	Trend change	Progressive increase	1.007	1.006;1.008	<0.0001
	Midwest				
	Level change	Abrupt reduction	0.936	0.926;0.946	<0.0001
	Trend change	Progressive increase	1.007	1.006;1.008	<0.0001
	Brazil				
	Level change	Abrupt reduction	0.939	0.918;0.960	<0.0001
	Trend change	Progressive increase	1.006	1.0054;1.007	<0.0001
	Black				
	Level change	Not detected	0.986	0.949; 1.025	0.503
	Trend change	Progressive increase	1.007	1.005.1.009	<0.0001
Race/Skin color	**White**				
	Level change	Abrupt reduction	0.884	0.851; 0.919	<0.0001
	Trend change	Progressive increase	1.006	1.005;1.007	<0.0001
	Firearm				
	Level change	Abrupt reduction	0.873	0.861;0.885	<0.0001
	Trend change	Progressive increase	1.005	1.005;1.006	<0.0001
	Autointoxication				
Methods	Level change	Abrupt reduction	0.982	0.972;0.991	<0.0001
	Trend change	Progressive increase	1.004	1.0044;1005	<0.0001
	HSS[d]				
	Level change	Abrupt reduction	0.936	0.912;0.960	<0.0001
	Trend change	Progressive increase	1.007	1.006;1.008	<0.0001

[a] Relative risk;[b]95% confidence interval;[c]interrupted time series estimated by the quasi-Poisson regression   model;[d]Hanging, strangulation and suffocation.

Table 4. Effect of the Covid-19 pandemic on suicide mortality rates per 100,000 women, Relative Risks estimated through interrupted time series analysis and by comparing the periods January 2017 to February 2020 with March 2020 to December 2022,Brazil,2024.

Variables	Categories	Interpretation	RR[a]	CI95%[b]	p-value[c]
	10 to 14				
	Level change	Not detected	0.917	0.648 ;1.296	0.624
	trend change	Not detected	1.008	1.000;1.017	0.053
Age group (years)	**15 to 19**				
	Level change	Not detected	0.959	0.789;1.165	0.674
	trend change	Progressive increase	1.007	1.002 ;1.011	0.0069
	20 to 39				

	Level change	Abrupt reduction	0.945	0.932 ;0.958	<0.0001
	trend change	Progressive increase	1.105	1.101 ;1.108	<0.0001
	40 to 59				
	Level change	Not detected	1.004	0.895 ;1.127	0.9414
	trend change	Not detected	1.003	1.000 ;1.005	0.0689
	60 or more years				
	Level change	Not detected	1.087	0.913;1.295	0.352
	trend change	Not detected	0.996	0.989;1.003	0.732
	North				
	Level change	Abrupt reduction	0.920	0.865 ;0.937	<0.0001
	Trend change	Progressive increase	1.008	1.007 ;1.009	<0.0001
	Northeast				
	Level change	Not detected	1.047	0.909 ;1.205	0.5262
	Trend change	Progressive increase	1.004	1.000 1.007	0.0312
	Southeast				
	Level change	Not detected	1.046	0.940;1.164	0.4127
	Trend change	Progressive increase	1.004	1.001;1.006	0.0048
Locality	**South**				
	Level change	Not detected	0.957	0.904 ;1.014	0.139
	Trend change	Progressive increase	1.005	1.004;1.006	<0.0001
	Midwest				
	Level change	Abrupt reduction	0.889	0.869 ;0.909	<0.0001
	Trend change	Progressive increase	1.007	1.007;1.008	<0.0001
	Brazil				
	Level change	Not detected	0.985	0.969;1.000	0.055
	Trend change	Progressive increase	1.005	1.001;1.006	<0.0001
	Black				
	Level change	Not detected	0.950	0.857 ;1.053	0.334
	Trend change	Progressive increase	1.007	1.005;1.010	<0.0001
Race/Skin color	**White**				
	Level change	Not detected	0.995	0.908 ;1.090	0.914
	Trend change	Progressive increase	1.004	1.001 1.006	0.002
	Firearm				
	Level change	Not detected	1.12	0.848;1.479	0.427
	Trend change	Not detected	0.996	0.989;1.003	0.24
	Autointoxication				
Methods	Level change	Not detected	1.04	0.897;1.206	0.607
	Trend change	Not detected	1.004	1.000;1.007	0.05
	HSS[d]				
	Level change	Abrupt reduction	0.947	0.926;0.968	<0.0001
	Trend change	Progressive increase	1.006	1.005;1.007	<0.0001

[a] Relative risk;[b]95% confidence interval;[c]interrupted time series estimated by the quasi-Poisson regression model;[d]Hanging. strangulation and suffocation.

4. Discussion

Our findings indicate higher suicide rates among women and men residing in the South and Midwest regions, with the most common methods being hanging, strangulation/suffocation, and with higher suicide rates observed particularly among white individuals. In both genders and across all variables considered, there was a marked increase in the monthly average rates of suicide during the pandemic. Using interrupted time series analysis to assess the pandemic's effect, we identified both level shifts (the immediate impact of the Covid-19 pandemic) and trend changes (the long-term effect of the Covid-19 pandemic) for most of the variables under study. The intervention (the Covid-19 pandemic) initially led to an abrupt reduction in monthly suicide rates (especially among men); however, this was followed by a progressive increase throughout the pandemic.

Brazil, along with its regions, has demonstrated a long-term upward trend in suicide rates over the past two decades [2,67-70]. Historically, the South and Midwest regions have presented the highest suicide rates; nonetheless, in recent years, the Northern region has also emerged as a significant area for suicide, particularly among women [2,67-70]. These findings are consistent with our results, which indicate higher suicide rates among both men and women in these regions, both before and during the Covid-19 pandemic [2,67-70]. The South region's identity is significantly shaped by European colonization, a population that historically shows elevated suicide rates [71-72]. It is worth noting that the Midwest region experienced a significant influx of migrant workers from the South in the 1970s, leading to cultural similarities with the South [71-72]. Additionally, both regions are highly dominated by agribusiness, and rural workers face greater risks of suicidal behavior due to job instability, limited access to healthcare services, and easy access to insecticides and pesticides [71-72].

The high suicide rates observed in the Midwest and North regions could be linked to their demographic composition and geographical location. These Brazilian regions have a high concentration of Indigenous populations and include border municipalities along the Northern and Central Arcs, areas marked by instability, violence, and international trafficking of drugs, goods, and people. Such conditions render Indigenous populations, women, and children particularly vulnerable to violence, which heightens the risk of suicide within these groups [2,73-75].

When examining the effect of the pandemic on monthly suicide rates between January 2017 and December 2022, we observed an initial level shift with a sharp reduction, followed by a progressive level increase. Notably, among women residing in the Northeast, Southeast, and South regions, no level shift was detected, though a trend change with progressive increases was observed throughout the pandemic. On the other hand, among men residing in the Northeast region, the pandemic yielded an abrupt and progressive increase in monthly suicide rates.

At the onset of the pandemic, it was believed that there would be an increase in suicide rates due to social isolation, fear of the unknown, anxiety about infecting oneself or family members, and socioeconomic impacts such as unemployment, food insecurity, and the lack of medical assistance for managing psychosocial issues [6-9]. Despite this assumption, studies have shown a reduction in suicides immediately following events such as terrorist attacks [27-29], natural disasters [11,76], the initial months following the Spanish flu pandemic (1918) [23], the SARS epidemic (2003) [11], and the Covid-19 pandemic [19-22,33-35,77-78]. Nevertheless, it is important to highlight that a subsequent rise in suicides over time has been observed following these events [11,22-23,27-29,34].

In our study, the pandemic precipitated an abrupt change, leading to a reduction in monthly suicide rates among men across all regions. Among women, however, we observed this effect solely in the North and Midwest regions. The reduction in suicide rates in Brazil was also documented in other Brazilian studies conducted during the first and second years of the pandemic [2,34,39]. We believe these findings may be associated with the social phenomenon of increased social cohesion, which tends to emerge during external threats—such as wars, epidemics, pandemics, natural disasters, and terrorist attacks . During these periods, social cohesion temporarily increases and may help mitigate the risk of suicide [11,26-28,76-78]. Min et al. [35] argues that social distancing and anxiety due to the rapid surge in confirmed cases and deaths during the early waves of the Covid-19 pandemic may have further strengthened social cohesion and altruism, resulting in fewer instances

of suicidal behavior. Furthermore, governmental measures offering financial assistance to vulnerable populations likely contributed to the reduction in suicides [22,33,35,79].

Another important factor in the reduction of suicides was the increased time spent at home with family members, considering that the majority of suicides typically occur in households. Additionally, the restrictions on movement during the early waves of the SARS-CoV-2 pandemic likely contributed to a decrease in suicides in public spaces [2,22,32-33,35,67-70,79]. Moreover, the excess number of deaths directly attributable to Covid-19 may have impacted individuals at high risk of suicide, indirectly contributing to a reduction in deaths from this health issue. In Brazil, during the first year of the pandemic, there was a 19% rise in deaths, mostly driven by infectious and parasitic diseases, whose increase exceeded 400% (SMR=4.80; 95%CI 4.78–4.82). In contrast, deaths from external causes declined by 4% compared to the expected number of fatalities [80].

However, these factors were insufficient to reduce the monthly suicide rates at the onset of the pandemic among men residing in Brazil's Northeast region. In this population, we observed an abrupt increase of 3.6% in monthly suicide rates, illustrating the pandemic's detrimental effect. This region faces long-standing socioeconomic inequalities and health disparities [50,81], which were only exacerbated during the pandemic, much like the trends observed in other studies conducted in Brazil during the first pandemic year [25] and in Nepal [24]. It is important to note that, in Nepal, the pandemic had more pronounced impacts in provinces with lower socioeconomic development [24].

Remarkably, across all regions and gender groups, there was a noticeable shift in trends, with progressive increases in monthly suicide rates. These results align with observations from Japan [22] and another Brazilian study that analyzed suicide rates until the second year of the pandemic [2]. Over time, after moments of significant social and economic upheaval, the breakdown of solidarity and social cohesion contributes to an increased prevalence of mental disorders, thereby fueling a rise in suicide numbers— a trend that may extend into the years following the pandemic [11,22-23,34-35].

Given this scenario, it becomes imperative to consistently examine the rise in suicides attributable to the pandemic, even after its official end. The Brazilian healthcare system and its Psychosocial Care Network must prepare to address these harmful effects in the long term [2,18]. Suicide prevention policies must also take an intersectoral approach, involving the entirety of civil society. These strategies should account for a multiplicity of contextual factors, including socioeconomic, cultural, and demographic elements, as well as individual influences on suicidal behavior [2,18,22,33,35,79]. Research conducted in the aftermath of natural disasters and health crises suggests that women, adolescents, older adults, individuals with a history of mental health problems, those who have lost loved ones, or those who face inadequate social and economic support are historically more vulnerable to suicidal behavior. Thus, providing psychosocial support to these populations following crises becomes essential to mitigate these impacts [11,22-23,34-35].

Within this framework of prevention, it is crucial to acknowledge that the suicidal behavior of men and women is shaped by traditionally defined gender roles in a patriarchal society. Although men tend to have higher suicide rates than women, women exhibit a higher incidence of suicide attempts and are more profoundly affected by suicidal behavior [43-48]. In the context of natural disasters, health crises, economic upheavals, and wars, research points to an increased risk of mental health problems and suicide, particularly among women, due to heightened violence and poverty in these groups [11,22-23,34-35]. In this regard, studies have highlighted a greater excess of suicide deaths among women compared to men during the Covid-19 pandemic [22,24,78].

Considering the findings of our study, it is noteworthy that men residing in Brazil, across all regions, exhibited a reduction in monthly suicide rates as an initial effect of the pandemic. However, among women, this decrease was only observed in the North and Central-West regions. Brazilian women, in general, have been more intensely impacted by the pandemic, suffering from income loss, increased unpaid domestic work due to the closure of daycare centers and schools, and the loss of family members, particularly if those individuals had a significant role in contributing to the household income [2,22,33]. Furthermore, extended proximity to domestic abusers increased their exposure to domestic violence, exacerbating the pandemic's effects on their mental health [82-85]. In

light of this, the increase in solidarity networks during this period likely had a limited effect in mitigating suicide rates among women residing in Brazil, at the onset of the pandemic.

Intersectionality between age and gender reveals differing patterns between men and women. Among men, age shows an increasingly strong association with suicide risk as it advances. In women, however, this trend is characterized by an increase in suicide rates from ages 15 to 19, followed by a progressive decline until age 60 and older.

In our study, the intersection of gender and life cycle also revealed differences in the temporal patterns of monthly suicide rates between men and women residing in Brazil. Among women, higher rates were observed in adolescents (ages 15 to 19) and middle-aged women (ages 40 to 59). Conversely, among men, a positive gradient was observed with increasing age, with the highest rates in the elderly population (60 years or older). Among men residing in Brazil, the pandemic's effects included both a level shift (an abrupt reduction) and a trend change (gradual increase) in adolescents, young adults, and middle-aged men. For women, an abrupt decline in monthly suicide rates (level shift) was detected solely among those aged 20 to 39. Moreover, a trend shift characterized by a progressive increase in monthly suicide rates throughout the pandemic was found in adolescent girls (15 to 19 years) and middle-aged women (20 to 39 years).

Brazilian adolescent, young adult, and middle-aged men possibly benefited more from protective factors during the pandemic, such as increased social cohesion, family contact, and household surveillance compared to women. This may explain the initial reduction in men's monthly suicide rates. Despite recent advances towards gender equality, Brazil remains a highly patriarchal, conservative country marked by elevated rates of violence against women and femicide [44,48,70,72,83-84]. We believe that the gender inequalities exacerbated during the socio-economic crisis triggered by the pandemic disproportionately intensified the psychosocial burden on women compared to men [44,48,70,72,83-84].

Over time, the pandemic resulted in increased monthly suicide rates among adolescents and young adults (20 to 39 years) of both genders. These findings align with observations from other countries during the Covid-19 pandemic, natural disasters, and public health crises [11,22-23,27-29,34]. Younger individuals may possess fewer coping mechanisms to deal with the stress associated with the pandemic than their older counterparts, thus contributing to a higher prevalence of mental health issues and suicide attempts [77-78].

Even prior to the pandemic, Brazilian adolescent girls and middle-aged women already exhibited higher suicide rates and greater suicide risk compared to older female cohorts [2,69-70]. Gender-based violence, teenage pregnancies, and a lack of social support are significant risk factors among girls and adolescents. Among middle-aged women, suicidal behavior may be influenced by the interplay between gender-based violence and socioeconomic stressors such as unemployment, underemployment, and the physical and mental burden of managing both unremunerated domestic labor and paid work [86-88].

Suicide risk and deaths of despair in young and middle-aged men during economic and health crises have been linked to unemployment, income loss, and the worsening living conditions of their families [75,77-78]. It is important to note that financial aid policies were gradually reduced in the second year of the pandemic and then fully withdrawn in subsequent years. We hypothesize that this legislative shift likely contributed to the progressive increase in monthly suicide rates during and after the pandemic [11,22-23,27-29,34]. Furthermore, these conditions heightened the vulnerability of individuals with lower educational attainment and income. Supporting this, a study conducted in Brazil during the 2015-2019 economic crisis indicated that suicide rates disproportionately increased among people with lower levels of education (12.5%; RR = 1.125; 95CI%: 1.027-1.232) during the 2014-2017 economic downturn [60].

Among the elderly, we observed pandemic-related effects only in men, with a rise in monthly suicide rates at the onset of the pandemic that persisted throughout. This demographic was the primary risk group for severe Covid-19 complications and death, factors that may have exacerbated mental suffering and suicidal behavior among them [75,77-78]. Moreover, elderly Brazilians have lower educational attainment and limited digital literacy compared to younger populations, which

likely hindered their communication with friends, family, and healthcare services, exacerbating isolation, loneliness, and despair [25,31,34,39].

Our findings also indicate heterogeneity between men and women by suicide method.Among men, we observed pandemic-related effects characterized by a decrease in monthly suicide rates across all studied methods at the beginning of the pandemic, followed by an increase throughout the pandemic. Among women, the pandemic's effects were only detected in the temporal evolution of suicides using the HSS method. Remarkably, HSS was the most commonly used method for both men and women. However, in second place, men predominantly used firearms, whereas women primarily opted for autointoxication. Suicide method choice typically reflects socio-cultural acceptability tied to normative gender roles and the accessibility of means [44-48]. In this context, it is important to note that Brazil had reduced the risk of firearm suicides following restrictive policies on weapon and ammunition sales and the regulation of firearm registration and possession at the national level [2,68-69]. Nevertheless, under the administration of Jair Bolsonaro, these measures were relaxed, facilitating firearm purchases and possession [83-84], which may have contributed to the increase in firearm-related suicide rates among men during the pandemic. Increased household availability of firearms could raise post-pandemic suicide risks. The rise in self-poisoning suicides among men during the pandemic may be attributed to the increased availability of poisons, particularly pesticides and medications, across Brazil [2,68-69]. Equally alarming is the rise in HSS suicides among both men and women during the pandemic. This method is among the most lethal, exacerbated by the fact that hanging is an easily accessible means with effective preventive measures only available in institutional settings, such as hospitals and prisons.

This situation underscores the need for suicide prevention policies that account for cultural, social, and political factors in the availability and acceptability of lethal means. Regardless of the specific method employed, attention must be given to preventing suicides, as such deaths are considered largely preventable. One potential barrier in restricting access to means is the substitution hypothesis, which posits that if one method becomes unavailable, it may be replaced by another. However, it is essential to consider that suicidal crises tend to be brief, and individuals often show a preference for specific methods. Therefore, restriction of access could play a significant role in delaying suicide attempts until the immediate crisis passes. Additionally, restricting access to more lethal means may increase the likelihood of survival, even in cases where substitution occurs [1,2,44-48].

Our analyses by gender and race/skin color suggest shifts in both level and trend, with monthly suicide rates initially decreasing among white men at the outset of the pandemic. Prior to and during the pandemic, both white men and women exhibited higher monthly suicide rates than their black counterparts. However, Afrodescendants faced higher homicide rates and were at greater risk of dying from Covid-19 during the pandemic [52,83-84]. Brazil's social and cultural framework was built on over 300 years of African slavery, where value is placed on life based on skin color—closer to the white European phenotype being held in higher regard—promoting anti-black racism. This contributes to Afrodescendant populations consistently demonstrating worse outcomes in health, education, employment, and income, inequities that were exacerbated by the pandemic [52]. In contrast to the United States, where the 2008 economic crisis increased the risk of deaths of despair (suicide, overdose, liver cirrhosis) among middle-aged white men, during Brazil's economic crisis following 2014, Afrodescendants bore the brunt of these deaths, with mortality likelihood increasing with skin pigmentation. Mixed-race individuals had a 21% higher prevalence of death by despair compared to whites (PR = 1.21, 95% CI 1.20–1.22), while black individuals had a 36% higher probability (PR = 1.36, 95% CI 1.34–1.37) [89].

In our study, the interaction between the racial inequality marker (race/skin color) and gender contributed to the mental health protective effects observed during the early stages of the pandemic, which were limited to Brazilian white men. This group exhibited an 11.6% reduction in monthly suicide rates at the outset of the pandemic. In contrast, no such effect was detected in black men, white women, or black women. Over time, monthly suicide rates increased among white and black men, as well as among white and black women. These findings mirror observations made in Brazil

during the 2014-2017 economic crisis, when monthly suicide rates rose by 0.4% among white and black Brazilians [60].

Our study presents two main limitations. The first relates to the quality of information regarding suicide records in Brazil's Mortality Information System. In light of this limitation, we chose to analyze the period from 2017 to 2022, as there were significant changes in the quality of this system over the last decade. The second limitation pertains to the method used, which does not allow for the identification of underlying causes or mechanisms related to suicides during the pandemic. However, the Interrupted Time Series (ITS) method enables us to analyze the pandemic's effect on the temporal evolution of monthly suicide rates. It also allows us to formulate hypotheses about factors potentially associated with changes in level and trend.Our findings were consistent with the effects observed during other health crises, natural disasters, and the COVID-19 pandemic on the temporal evolution of suicides. The using ITS analyses adjusted for seasonality and temporal trend on monthly suicide data supports the robustness of the findings

These findings emphasize the importance of public policies focused on regional interventions and specific populations, such as strengthening the Psychosocial Care Network, especially in areas with higher suicide incidence. Moreover, it is crucial to implement mental health support programs that encompass social, racial, and economic determinants, recognizing the distinct needs of men and women at different life stages. The progressive increase in suicide rates throughout the pandemic further points to the urgent need for preventive measures aimed at mitigating future public health crises, ensuring that mental health policies and psychosocial support are integrated into national emergency strategies, with an emphasis on vulnerable populations.

5. Conclusions

The findings of this study highlight the impact of the Covid-19 pandemic on monthly suicide rates in Brazil and across its five regions. Statistically significant changes in both level and trend were observed, characterized by an abrupt initial decline followed by a progressive increase in these rates, with notable differences between men and women. Among men, a reduction in monthly suicide rates was noted at the start of the pandemic across all regions, particularly among adolescents, young adults, middle-aged men, white men, and across all suicide methods analyzed. Among women, this early pandemic reduction in monthly suicide rates was observed only in two regions (Northeast and Midwest), among young adults, and specifically in suicides by hanging. This initial decrease was subsequently followed by a progressive increase throughout the pandemic for both men and women in most variables studied.

Our findings suggest that increased social cohesion, solidarity, and the emergency financial assistance measures implemented at the onset of the pandemic may have contributed more significantly to the reduction in suicides among men compared to women, particularly when considering regional variations, life stages, race/ethnicity, and suicide methods. However, the rise in suicide rates for both genders over the course of the pandemic may continue into the post-pandemic period, an issue warranting close attention in future research and suicide prevention strategies.Therefore, it is crucial for the Brazilian government to develop intersectoral suicide prevention strategies that engage civil society and address the important regional, racial, and life-cycle differences, as well as the most prevalent suicide methods in the country, to mitigate this public health challenge in future health crises.

Supplementary Materials: The following supporting information can be downloaded at: Preprints.org. Fig S1: Smoothed Monthly Suicide Rates per 100,000 men using LOESS (Locally Estimated Scatterplot Smoothing), by methods, Brazil, 2024. Fig S2: Smoothed Monthly Suicide Rates per 100,000 Women using LOESS (Locally Estimated Scatterplot Smoothing), by methods, Brazil, 2024.Fig S3: Smoothed Monthly Suicide Rates per 100,000 inhabitants using LOESS (Locally Estimated Scatterplot Smoothing), by race skin color, Brazil, 2024.Fig S4: Smoothed Monthly Suicide Rates per 100,000 men using LOESS (Locally Estimated Scatterplot Smoothing), by age group,Brazil, 2024.Fig S5: Smoothed Monthly Suicide Rates per 100,000 women using LOESS (Locally Estimated Scatterplot Smoothing), by   age group, Brazil, 2024.

Institutional Review Board Statement: The research was conducted using freely available data from SIM/DATASUS, where no identification of individual subjects occurs, and therefore there was no need to submit the study to a Research Ethics Committee, in accordance with Article 1 of CNS Resolution No. 510, dated April 7, 2016

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Data Availability Statement: After approval of the manuscript, the databases and R codes will be made available in the Zenodo repository.

Conflicts of Interest: The authors declare no conflicts of interest.

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