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TRENDS AND FACTORS ASSOCIATED WITH FIREARM-RELATED MORTALITY IN BRAZIL, 1996-2022: ECOLOGICAL STUDY

TENDÊNCIA E FATORES ASSOCIADOS À MORTALIDADE POR ARMA DE FOGO NO BRASIL, 1996-2022: ESTUDO ECOLÓGICO

TENDENCIA Y FACTORES ASOCIADOS A LA MORTALIDAD POR ARMAS DE FUEGO EN BRASIL, 1996-2022: ESTUDIO ECOLÓGICO

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Objective: to analyze the temporal trend and factors associated with firearm-related mortality in Brazil between 1996 and 2022. Method: time series study. The *Joinpoint Regression Program*® software was used to analyze the annual percentage change and the average annual percentage change. The correlation between deaths and socioeconomic indicators was performed using linear regression. Results: A stationary trend was observed in Brazil. In the North and Northeast regions, there was a significant increase. The Southeast and Midwest regions showed a downward trend. A higher Atkinson index (β=1439.99; p=0.042) and greater loss in Inequality-Adjusted Income (β=14.40; p=0.042) are positively associated with higher mortality. A lower proportion of young people between 18 and 24 years of age with complete elementary education and a decrease in the proportion of income are related to higher mortality (β=-21.42; p=0.011; β=-11.58; p=0.043, respectively). Conclusions: Brazil showed stability in firearm-related mortality, with variations between regions of the country.

Descriptors: Firearm Violence. Time Series Studies. Public Health. Ecological Studies. Mortality.

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*Objetivo: analisar a tendência temporal e fatores associados à mortalidade por arma de fogo no Brasil entre 1996 e 2022. Método: estudo de séries temporais. Utilizou-se o software Joinpoint Regression Program® para analisar a variação percentual anual e a variação percentual anual média. A correlação entre os óbitos e indicadores socioeconômicos foi realizada por regressão linear. Resultados: foi observada tendência estacionária no Brasil. Nas Regiões Norte e Nordeste, houve aumento significativo. Sudeste e Centro-Oeste apresentaram tendência de declínio. Maior índice de Atkinson (β=1439,99; p=0,042) e maior perda na Renda Ajustado à Desigualdade (β=14,40; p=0,042) estão positivamente associados com mortalidade mais alta. Menor proporção de jovens entre 18 e 24 anos com ensino fundamental completo e diminuição na proporção da renda estão relacionadas à mortalidade mais elevad*a (β=*-21,42; p=0,011;* β=*-11,58; p=0,043, respectivamente) Conclusões: o Brasil demonstrou estabilidade na mortalidade por armas de fogo, com variações entre as regiões do país.*

Descritores: Violência com Arma de Fogo. Estudos de Séries Temporais. Saúde Pública. Estudos Ecológicos. Mortalidade.

Objetivo: analizar la tendencia temporal y los factores asociados a la mortalidad por armas de fuego en Brasil entre 1996 y 2022. Método: estudio de series temporales. Se utilizó el software Joinpoint Regression Program® para analizar la variación porcentual anual y la variación porcentual media anual. La correlación entre las muertes y los indicadores socioeconómicos se realizó mediante regresión lineal. Resultados: se observó una tendencia estacionaria en Brasil. En las regiones Norte y Nordeste, hubo un aumento significativo. El Sudeste y el Centro-Oeste mostraron una tendencia a la baja. Un índice de Atkinson más alto (β=1439,99; p=0,042) y una mayor pérdida en la renta ajustada a la desigualdad (β=14,40; p=0,042) se asocian positivamente con una mayor mortalidad. Una menor proporción de jóvenes de entre 18 y 24 años con educación primaria completa y una disminución en la proporción de ingresos están relacionadas con una mayor mortalidad (β=-21,42; p=0,011; β=*-11,58; p=0,043, respectivamente). Conclusiones: Brasil mostró estabilidad en la mortalidad por armas de fuego, con variaciones entre las regiones del país.*

Descriptores: Violencia con Armas. Estudios de Series Temporales. Salud Pública. Estudios Ecológicos. Mortalidad.

Introduction

In Brazil, firearm-related mortality has been a persistent and significant concern over the last few decades. Statistics reveal a high prevalence of this problem[1], particularly with regard to the increasing and spreading to the interior of the areas at risk of homicide in Brazil[2]. In addition to the irreplaceable human cost, this manifestation of violence can be influenced by broad social factors, such as poverty and social exclusion, as well as factors associated with international criminal activities, such as drug and arms trafficking. This combination is described as problematic because it intensifies the negative effects of poverty and vulnerability, creating a cycle of violence and marginalization[3].

The severity of firearm-related mortality in Brazil cannot be underestimated, as it poses a threat to both public health and safety. This problem results in a number of premature and preventable deaths, causing a devastating impact on the families of those involved and the affected communities[4]. In addition, firearm injuries often lead to serious and chronic health complications, overwhelming health systems[5]. In terms of security, the proliferation of weapons is a challenge to maintaining public order and the integrity of the State, as these issues are often addressed in studies that indicate a relationship between the entry of firearms into society and an increase in firearm homicides[6].

The analysis of the temporal distribution of firearm deaths over a period of time allows for the identification of trends and patterns, which can provide information for understanding the dynamics of armed violence over time. By examining data over decades, it is possible to detect seasonal fluctuations, geographic variations, and changes in mortality rates that may be associated with socioeconomic, political, and demographic factors. In addition, this temporal analysis can reveal specific events or policies that have had a significant impact on firearm mortality, providing guidance for the formulation of effective public policies and interventions.

The study is expected to make significant contributions to several areas, including public health, criminology, public policy, and violence prevention. This may include measures such as strengthening gun control, investing in community-based violence prevention programs, and developing social and economic policies that address the structural roots of crime.

Previous studies on firearm-related deaths in Brazil have been essential. However, they have focused on deaths from violence from various causes or specified state or municipal units of analysis[7-8] or examined the country by region(6,9). However, these approaches may leave gaps in understanding the factors that contribute to armed violence. Thus, this study differs by analyzing Brazil as a whole, by state and region individually, allowing for a deeper understanding of the relationships between firearm mortality and socioeconomic indicators.

Therefore, the objective of this study was to analyze the temporal trend and factors associated with firearm-related mortality in Brazil between 1996 and 2022.

Method

This is an ecological time series study that analyzed mortality in the 27 states of Brazil. Data collection took place between February and March 2024. This study followed the recommendations of the Reporting of Studies Conducted Using Observational Routinely-Collected Health Data (RECORD).

The data were obtained from the electronic portal of the Brazilian Unified Health System's Department of Informatics (DataSUS) using the TabNet platform. Vital statistics were then collected from the Mortality Information System (SIM). Deaths from external causes in different years, states, and regions were selected according to place of residence and the International Classification of Diseases (ICD-10), using codes W32 to W34, X93 to X95, and Y22 to Y24. The period analyzed was from 1996, the initial year of data tabulation, to 2022, the last year with complete data. On this basis, variables such as race/skin color (white, yellow, black, brown, indigenous, or unknown), place of death (home or public place), and marital status (single, married, widowed, legally separated) were collected, excluding others and unknowns in the analysis.

To calculate the mortality rate, demographic and socioeconomic data for the resident population provided by DataSus were used. The options chosen were censuses (1980, 1991, 2000, and 2010), Counting [(1996)], and intercensal projections (1981 to 2012), according to age group, sex, and household situation, in addition to the projection of the Population of the Federation Units by sex, exact age, and age groups: 2010-2060 (2018 edition). Thus, for the mortality rate, the number of firearm-related deaths per region during the period was considered, divided by the total resident population of the same region during the period, multiplied by one hundred thousand.

In addition, sociodemographic variables were collected from the Atlas Brasil and Institute of Applied Economic Research (IPEA) websites. Socioeconomic indicators included the Atkinson Index – Income, the Municipal Human Development Index (IDHM) Income Adjusted for Inequality (IDHMAD Income) – Loss due to inequality, the percentage of 18- to 24-year-olds with complete elementary education, the percentage of income from labor, the average per capita income of the poorest quintile, the Gini Index (an indicator that measures income distribution inequality), and the Social Vulnerability Index (an indicator of access, absence, or insufficiency of assets in Brazilian territory, such as human capital, income and labor, and urban infrastructure).

All data available online was downloaded in CSV format. Subsequently, it was organized into a single Microsoft Office Excel® spreadsheet and the data was grouped by municipality, each with its respective geocode.

Initially, the data were imported into *Joinpoint Regression Program*® version 4.6.0.0 software, where segmented regression analyses were performed to identify inflection points (*joinpoints*). The analysis involved calculating

the annual percentage change (APC) with a 95% confidence interval (95% CI). A negative APC value indicates a decreasing trend, while a positive value indicates an increasing trend[10]. In addition, the average annual percentage change (AAPC) was calculated, which provides an overview of the change over the period. The model was adjusted to allow up to three segments of change in the linear trend, and the results were considered significant for values of $p < 0.05$.

To assess how these variables individually contribute to the mortality rate, a simple linear regression analysis was performed using Jamovi® software. The β coefficients, their 95% confidence intervals (95% CI), and p-values were calculated for each variable, indicating statistical significance when $p < 0.05$.

As this study was based on previously published secondary data, submission to or approval by a human research ethics committee was not required.

Results

During the period analyzed, Brazil had a rate of 19.34 firearm-related deaths per 100,000 inhabitants (991,482 deaths). With regard to gender, males were the most affected, accounting for 93.95% of total deaths. Both genders showed a stationary trend. In the analysis by skin color, the brown population was the most affected, accounting for 61.74% of deaths, with an average annual change rate indicating an upward trend (AAPC: 21.7; 95% CI: 17.9; 25.6). Concerning marital status, single people represented the majority of cases (79.23%). Regarding the location of occurrence, most deaths occurred on public places (82.02%), with an annual change rate indicating an increasing trend (AAPC: 1.0; 95% CI: 0.0; 1.9). On the other hand, cases at home accounted for 17.98% of the total, with the average annual change rate also indicating growth (AAPC: 1.6; 95% CI: 0.6; 2.7) (Table 1).

Table 1 – Percentage change in the number of firearm-related deaths in Brazil. Fortaleza, Ceará, Brazil – 1996-2022. (N=990,622)

Location	n	%	AAPC	CI95%	p-value	Trend
Gender						
Male	930,715	93.95	0.3	-12.2; -3.3	0.487	Stationary
Female	59,907	6.05	-0.4	0.2; -1.2	0.227	Stationary
Skin color						
White	260,614	29.17	10.7*	8.1; 13.5	0.001	Increasing
Black	77,529	8.68	16.9	14.1; 19.7	0.001	Increasing
Yellow	2,302	0.26	-4.4	-7.9; -0.8	0.016	Decreasing
Brown	551,618	61.74	21.7	17.9; 25.6	0.001	Increasing
Indigenous	1,419	0.16	4.4	3.0; 5.7	0.001	Increasing
Marital status						
Single	708,871	79.23	1.0	-0.1; 2.2	0.067	Stationary
Married	126,454	14.13	-3.1	-3.8; -2.3	0.001	Decreasing
Widowed	6,312	0.71	-2.2	-3.2; -1.2	0.001	Decreasing
Legally separated	20,045	2.24	3.1	1.9; 4.3	0.001	Increasing
Place of occurrence						
Home	99,889	17.98	1.6	0.6; 2.7	0.002	Increasing
Public places	455,654	82.02	1.0	0.0; 1.9	0.039	Increasing

Source: own elaboration.

Legend: AAPC = Average Annual Percentage Change; 95% CI = 95% Confidence Interval.

Table 2 presents the analysis of trends in Brazil. A stationary trend was observed in the country (AAPC: -0.3; 95% CI: -0.3; 0.8). In the North (AAPC: 3.3; 95% CI: 1.9; 4.6) and Northeast (AAPC: 2.6; 95% CI: 1.8; 3.4) regions, there was a significant increase. In the Southeast (AAPC:

-3.3; 95% CI: -4.4; -2.1) and Midwest (AAPC: -2.0; 95% CI: -2.8; -1.1), a downward trend was observed. In the South, rates remained stable (AAPC: 0.2; 95% CI: -1.0; 1.4). Of the 27 states, eight showed an upward trend: Piauí, Ceará, Maranhão, Bahia, Pará, Rio Grande do Norte, Paraíba, and Amazonas. Eight states showed a decrease in rates: the Federal District, Rio de Janeiro, São Paulo, Mato Grosso do Sul, Espírito Santo, Pernambuco, Rondônia, and Mato Grosso. The other 11 states remained stable.

Table 2 – Annual percentage change in firearm-related mortality in Brazil by location. Fortaleza, Ceará, Brazil – 1996-2022. (N=990,622)

Location	APC1 (IC95%	IP	APC2 (IC95%)	IP	APC3 (IC95%)	AAPC (IC95%)
Brazil	5,6* (0,3; 11,2)	200	0,5 (-0,2; 1,1)	2017	-7,2* (-10,5; -3,7)	-0,3 (-0,3; 0,8
North	5,9* (5,1; 6,7)	2017	-7,2* (-12,9; -1,0)	-	-	3,3* (1,9; 4,6)
Acre	-4,4 (-7,0; -1,7)	2011	33,4* (15,1; 54,5)	2017	-17,7*(-28,9; -4,7)	0,3 (-4,0; 4,8)
Amapá	-16,7* (-28,8; -2,4)	2000	1,0 (-5,5; 7,9)	2008	8,4* (5,8; 10,9)	1,8 (-1,4; 5,1)
Amazonas	-5,9* (-9,7; -1,8)	2003	15,7* (10,9; 20,6)	2011	1,3 (-0,8; 3,5)	3,5* (1,6; 5,4)
Pará	12,1* (10,3; 13,9)	2009	3,4 (0,0 ; 7,0)	2018	-14,1*(-22,1; -5,3)	4,6* (2,6; 6,7)
Rondônia	-1,2* (-1,9; -0,4)	-	-	-	-	-1,2* (-1,9; -0,4)
Roraima	-7,9* (-9,9; -5,9)	2011	19,8* (10,0; 30,5)	2018	-10,9 (-24,0; 4,6)	-1,7 (-4,9; 1,7)
Tocantins	-0,8 (-0,8; -4,1)	2007	10,3* (5,4; 15,4)	2017	-5,3 (-15,2; 5,8)	2,4 (-0,5; 5,4)
Northeast	5,1* (4,6; 5,5)	2017	-7,3* (-10,8; -3,6)	-	-	2,6* (1,8; 3,4)
Alagoas	-6,6 (-21,8; 11,5)	1999	13,0* (10,4; 15,80	2011	-11,7 (-7,4; -8,8)	0,6 (-1,7; 3,0)
Bahia	5,1* (3,2; 7,0)	2006	23,8 (-1,7; 55,8)	2009	0,4 (-0,8; 1,6)	4,7* (1,9; 7,4)
Ceará	10,5* (9,1; 12,0)	2017	-10,1 (-20,1; 0,9)	-	-	6,2* (3,7; 8,7)
Maranhão	-8,1 (-20,9; 6,7)	1999	14,1* (12,5; 15,7)	2014	-3,6* (-6,7; -0,4)	5,6* (3,5; 7,8)
Paraíba	6,0* (2,4; 9,8)	2004	14,8* (8,9; 21,2)	2011	-4,5* (-6,5; -2,5)	3,6* (1,7; 5,6)
Pernambuco	-1,7* (-2,6; -0,8)	-	-	-	-	-1,7* (-2,6; -0,8)
Piauí	17,8* (8,7; 27,6)	2002	6,8 (5,4; 8,2)	-	-	9,2* (7,0; 11,4)
Rio Grande do Norte	1,3 (-3,7; 6,7)	2002	12,0* (10,4; 13,6)	2017	-12,9* (-18,6; -6,7)	4,3* (42,4; 6,2)
Sergipe	3,8* (1,7; 5,9)	2010	16,5* (5,8; 28,4)	2016	-11,8* (-18,1; -5,1)	2,7 (-0,2; 5,6)
Southeast	6,5* (0,5; 12,8)	2001	-5,5* (-6,1; -4,8)	-	-	-3,3* (-4,4; -2,1)
Espírito Santo	2,2* (0,5; 3,8)	2009	-5,6* (-7,1; -4,1)	-	-	-1,8* (-2,8; -0,7)
Minas Gerais	15,2* (10,5; 20,0)	2004	0,1 (-2,4; 2,6)	2016	-12,4* (-17,8; -6,7)	1,3 (-0,8; 3,5)
Rio de Janeiro	-4,6* (-5,2; -4,0)	-	-	-	-	-4,6* (-5,2; -4,0)
São Paulo	15,9* (9,8; 22,3)	2001	-15,7* (-20,1;-11,1)	2007	-5,8* (-6,8; -4,9)	-4,5* (-6,0; -2,9)
South	5,0* (3,7; 6,3)	2008	-0,3 (-3,0; 2,5)	2016	-8,3* (-11,4; -5,1)	0,2 (-1,0; 1,4)
Paraná	7,9* (6,6; 9,2)	2009	-6,1* (-7,3; -5,0)	-	-	0,6 (-0,2; 1,5)
Rio Grande do Sul	1,7* (0,9; 2,5)	2013	12,5 (-9,6; 39,9)	2016	-11,1* (-14,3; -7,8)	-0,3 (-2,8; 2,3)
Santa Catarina	3,4* (2,2; 4,5)	2016	-11,6*(-17,4; -5,4)	-	-	-0,3 (-2,0; 1,4)
Midwest	-0,4 (-1,6; 0,8)	2006	4,1* (2,3; 5,9)	2015	-11,28(-13,1; -9,3)	-2,0* (-2,8; -1,1)
Distrito Federal	-0,3 (-1,2; 0,6)	2014	-15,9* (-18,4; -13,2)	-	-	-5,4* (-6,4; -4,3)
Goiás	3,9* (2,5; 5,3)	2007	7,3* (5,0; 9,8)	2016	-16,0* (-18,9; -3,1)	0,0 (-1,1; 1,2)
Mato Grosso	-0,8* (-1,5; -0,1)	-	-	-	-	-0,8* (-1,5; -0,1)
Mato Grosso do Sul	-3,9* (-4,5; -3,4)	-		-	-	-3,9* (-4,5; -3,4)

Source: own elaboration.

Note: Conventional symbol used: Numerical data not applicable.

Legend: APC = Annual Percentage Change; IP = Inflection Point; AAPC = Average Annual Percentage Change; 95% CI = 95% Confidence Interval; *Statistically significant (<0.05).

In the North Region, there was a significant increase in mortality in Amazonas (AAPC: 3.5; 95% CI: 1.6; 5.4). In Pará, this variation was even more pronounced (AAPC: 4.6; 95% CI: 2.6; 6.7). On the other hand, Rondônia recorded a decrease (AAPC: -1.2; 95% CI: -1.9; -0.4).

In the Northeast Region, there was a significant increase in mortality in some states. Piauí had the

largest increase (AAPC: 9.2; 95% CI: 7.0; 11.4), followed by Ceará (AAPC: 6.2; 95% CI: 3.7; 8.7), Maranhão (AAPC: 5.6; 95% CI: 3.5; 7.8), Bahia (APAC: 4.7; 95% CI: 1.9; 7.4), Rio Grande do Norte (APAC: 4.3; 95% CI: 4.2; 6.2), and Paraíba (APAC: 3.6; 95% CI: 1.7; 5.6). In Pernambuco, there was a decrease in firearm-related mortality (AAPC: -1.7; 95% CI: -2.6; -0.8).

In the Southeast, there was a downward trend in deaths in all states analyzed. Rio de Janeiro had the most significant decrease (AAPC: -4.6; 95% CI: -5.2; -4.0), followed by São Paulo (AAPC: -4.5; 95% CI: -6.0; -2.9) and Espírito Santo (AAPC: -1.8; 95% CI: -2.8; -0.7).

In the Midwest, the Federal District showed the largest reduction (AAPC: -5.4; 95% CI: -6.4; -4.3), followed by Mato Grosso do Sul (AAPC: -3.9; 95% CI: -4.5; -3.4) and Mato Grosso (AAPC: -0.8; 95% CI: -1.5; -0.1).

Table 3 shows the relationship between socioeconomic indicators and firearm-related mortality in Brazil during the study period.

Table 3 – Association between socioeconomic indicators and firearm-related mortality in Brazil. Fortaleza, Ceará, Brazil – 1996-2022. (N=990,622)

Socioeconomic indicators	Coefficient	Error	p-value	CI95%
Atkinson Index - Income	1439,99	671,10	**0,042**	57,83; 2822,16
IAMU Income Adjusted for Inequality - Loss due to inequality	14,40	6,71	**0,042**	0,58; 28,22
Percentage of 18- to 24-year-olds who have completed elementary school	-21,42	7,81	**0,011**	-37,50; -5,34
Percentage of income from labor	-11,58	5,44	**0,043**	-0,37; -2,13
Average per capita income of the poorest quintile	-1,42	0,69	0,050	-2,83; -0,01
Gini Index	1597,34	839,06	0,069	-130,75; 3325,43
Social Vulnerability Index	1201,75	591,45	0,053	-16,37; 2419,88

Source: own elaboration.

MHDI = Municipal Human Development Index; CI = Confidence Interval.

Regarding socioeconomic indicators, it was found that a higher Atkinson index, indicating greater inequality, is positively related to higher mortality (β=1439.99; p=0.042). The Inequality-Adjusted Municipal Human Development Index (IDHM) - Loss due to inequality shows an association between the loss in the Municipal Human Development Index due to income inequality and deaths. A higher loss in the IDHM due to inequality is positively associated with higher mortality (β=14.40; p=0.042).

Regarding the percentage of 18- to 24-year-olds with complete elementary education and the percentage of income from work, an inverse association with deaths was observed. Thus, areas with a lower percentage of young people who have completed elementary school tend to have higher mortality (β=-21.42; p=0.011), as well as a decrease in the proportion of income from work is related to a higher death rate (β=-11.58; 0.043).

Discussion

Regarding gender, males were the most affected. The predominance of male deaths from firearms is intrinsically linked to a complex interaction of social, cultural, and economic factors. In many cases, men are more exposed to risky situations, such as involvement in criminal activities or armed conflicts, and are influenced by social norms that promote aggressive behavior. In addition, interpersonal disputes and rivalries can often result in lethal violence, with men more likely to engage in confrontations[11], and easier access to firearms in certain contexts also increases the risk of fatal violence[12].

It is also important to consider the underreporting of female deaths, which can distort the perception of the prevalence of violence between the sexes. Therefore, understanding and addressing these various factors is essential

to developing effective strategies for preventing and reducing lethal violence in all populations[13].

In the case of the North and Northeast regions, where significant increases in firearm-related mortality have been observed, several causes may contribute to this scenario. These regions often face socioeconomic challenges, such as high rates of poverty, social inequality, and limited access to basic health services[14]. In addition, the presence of organized crime, especially related to drug trafficking, can have a substantial influence, increasing the incidence of armed violence[15].

Structural issues, such as the lack of investment in public safety policies and the fragility of government institutions in some areas, may also contribute to the escalation of firearm-related deaths. Therefore, it is recommended that comprehensive public policies be developed that combine aspects of public safety and health services, prioritizing people's well-being, social interactions, and meeting individual needs. This aims to identify vulnerable regions and implement specific measures to effectively address these challenges[16].

The decrease in firearm-related mortality observed in the Southeast and Midwest can be attributed to a number of factors. In many states in these regions, more effective public policies focused on security have been implemented, including efforts to reduce the power and influence of criminal factions through more effective police operations, stricter security policies, and targeted violence prevention programs[17]. These actions, which aim to dismantle organized crime and reduce its capacity to operate, can have a significant impact on reducing firearm-related deaths[17].

In other South American countries, there is also complex data on crime trends. A study conducted between 2003 and 2012 reveals that Venezuela, Brazil, and Colombia had the highest homicide rates, driven by organized crime and social inequality. Colombia saw a gradual decrease in homicides, thanks to security policies and the demobilization of armed groups, while Venezuela experienced a significant increase. On the other hand, Chile and Argentina maintained lower rates, attributed to more effective security policies and less impact from organized crime[18].

Corroborating the above data, in 2009, the average homicide rate in the Americas was 15.5/100,000 inhabitants, with countries such as Venezuela, El Salvador, and Guatemala having the highest rates, while Chile and Canada were among the lowest. Venezuela and El Salvador saw alarming increases, while Colombia saw a drop in rates. Factors such as social inequality, urban violence, drug trafficking, and institutional fragility were identified as the main causes of these homicides, in some cases involving firearms[19].

It is important to note that the relationship between the stabilization of criminal factions and the decrease in armed violence is complex and multifaceted, and other factors may also be involved in this process[1]. In addition, improvements in socioeconomic conditions, such as increased access to education[17], may have contributed to the reduction in mortality.

In this study, there was an association between a higher Atkinson index, which reflects greater socioeconomic inequality, and higher rates of firearm-related deaths. In areas with higher levels of inequality, precarious socioeconomic conditions such as poverty, lack of access to basic services, and unemployment[20] are more likely to exist. In addition, inequality can create a sense of injustice and marginalization among certain segments of the population, leading to greater involvement in criminal activities as a way of seeking power, resources, or recognition in a society where opportunities are unequal[21].

From this perspective, government interventions play a crucial role in this context. Public policies aimed at increasing education, access to employment, and reducing socioeconomic inequality can contribute significantly to reducing firearm-related death rates[22]. It has also been shown that areas with a lower percentage of young people who have completed elementary school tend to have higher mortality rates. Thus, investing in quality, emancipatory education is fundamental to

promoting the social and economic development of a community[23]. This includes investments in quality education, professional training programs, the construction of new schools, improvements in the quality of teaching, teacher training, and the provision of comprehensive education programs. These measures can play a crucial role in reducing violence, as it provides opportunities for employment and income, reducing rates of inequality and social exclusion.

In addition to the aspects mentioned above, it is crucial to recognize the complexity and interconnection of a number of factors that contribute to firearm-related mortality. Therefore, it is imperative to adopt a multidimensional approach that considers not only income, education, and employment, but also issues related to mental health, public safety, social inequalities, and access to firearms when developing policies. The integration of different sectors of public administration and civil society is emphasized in order to obtain more effective responses in policy development and health service provision. In this context, it is important to strengthen society's involvement and social control over health policies and services, prioritizing their specific needs[24].

It is essential that the results of this study be contextualized within the promotion of a culture of peace and the implementation of the Sustainable Development Goals (SDGs) [25]. The SDG 16 seeks to promote peaceful and inclusive societies for sustainable development, providing access to justice for all and building effective and accountable institutions. Reducing firearm-related mortality is directly aligned with this goal, as armed violence is often associated with insecurity, social injustice, and institutional fragility. In addition, the implementation of measures to achieve other SDGs, such as quality education (SDG 4), gender equality (SDG 5), and reduced inequalities (SDG 10), can indirectly contribute to reducing violence by addressing underlying factors that fuel crime. Thus, it is important to recognize and promote an integrated approach that links the pursuit of the SDGs to the reduction of firearm-related mortality.

Some limitations are listed in the development of this study. Data quality may be compromised by registration failures, underreporting, or lack of standardization, affecting the accuracy of the analyses. In addition, the availability and coverage of data may be limited, which prevents complete longitudinal analyses or comparisons between different geographic areas. Thus, it is important to conduct new research investigating the causes and determinants of firearm death trends in each regional context, focusing on socioeconomic, cultural, and political factors that contribute to the observed disparities. In addition, it is crucial to explore public policy approaches that integrate different sectors, such as health, education, and public safety, in order to comprehensively address the challenge of armed violence.

The main contributions of this study are to highlight regional inequalities in firearm-related mortality and their relationship with socioeconomic factors, which broadens our understanding of the phenomenon. Furthermore, it demonstrates that armed violence requires intersectoral and integrated responses. In addition, the study contributes to guiding decentralized public policies that are tailored to regional specificities.

Conclusion

This study analyzed the temporal distribution and factors associated with firearm-related mortality in Brazil between 1996 and 2022. While Brazil as a whole showed stability in mortality, significant variations were observed between regions of the country. The North and Northeast regions recorded significant increases, while the Southeast and Midwest regions showed declines. This highlights the urgent need for specific policies and interventions that address the causes and determinants of these trends in each regional context, with a view to reducing firearm-related deaths throughout the country.

In addition, greater inequality, as measured by the Atkinson index and the loss in the IDHM, was associated with higher mortality. Lower educational attainment among young people and reduced income were also correlated with higher mortality rates. It is important to strengthen broad policies that bring together sectors such as health, education, and public safety to adequately address the challenge of armed violence. In addition, it is crucial to promote decentralized actions, encouraging each region or state to implement specific measures that meet their local needs and characteristics.

Collaborations:

1 – project design and planning: Nathanael de Souza Maciel, Kadson da Araujo Silva, Livia Karoline Torres Brito, Camila Chaves da Costa and Ana Kelve de Castro Damasceno;

2 – data analysis and interpretation: Nathanael de Souza Maciel, Kadson da Araujo Silva, Livia Karoline Torres Brito, Camila Chaves da Costa and Ana Kelve de Castro Damasceno;

3 – writing and/or critical review: Nathanael de Souza Maciel, Kadson da Araujo Silva, Livia Karoline Torres Brito, Camila Chaves da Costa and Ana Kelve de Castro Damasceno;

4 – approval of the final version: Nathanael de Souza Maciel, Kadson da Araujo Silva, Livia Karoline Torres Brito, Camila Chaves da Costa and Ana Kelve de Castro Damasceno.

Conflicts of interest

There are no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available in the article itself.

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