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ORIGINAL ARTICLES

Asthma mortality in Southern Brazil between 2013 and 2022: a time series analysis

Mortalidade por asma no Sul do Brasil entre 2013 e 2022: uma análise de séries temporais

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Abstract: Aims: To analyze asthma mortality in Rio Grande do Sul from 2013 to 2022 and understand the variation in asthma mortality over the years, including during the COVID-19 pandemic period. Methods: This is a descriptive time-series study with an ecological approach that analyzed asthma mortality in the state of Rio Grande do Sul, Brazil. Mortality data were extracted from the Mortality Information System, and population data were obtained from the 2010 and 2022 censuses. Results: A total of 1,885 deaths were identified in Rio Grande do Sul between 2013 and 2022, with a predominance of women (69.39%), an average age of 68.27 years (SD = 20.03), 65.22% hospitalized, and an average income of R$ 1,044.73 (SD = 441.35). A significant increase in the number of deaths and the mortality rate was observed over the period, with an annual percentage variation of 5.69%. Conclusion: Asthma mortality in Brazil remains significant and is increasing. We emphasize the importance of improvements in diagnosis, treatment, and public health actions for prevention and control.

Keywords: asthma, mortality registries, COVID-19, public health.

Resumo: Objetivos: Analisar a mortalidade por asma no Rio Grande do Sul de 2013 a 2022 e compreender a variação da mortalidade ao longo dos anos, incluindo o período da pandemia de COVID-19. Métodos: Este é um estudo descritivo de séries temporais com abordagem ecológica que analisou a mortalidade por asma no estado do Rio Grande do Sul, Brasil. Os dados de mortalidade foram extraídos do Sistema de Informações sobre Mortalidade, e os dados populacionais foram obtidos dos censos de 2010 e 2022. Resultados: Foram identificados 1.885 óbitos no Rio Grande do Sul entre 2013 e 2022, com predominância de mulheres (69,39%), com idade média de 68,27 anos (DP = 20,03), 65,22% provenientes de hospitalizações e renda média de R$ 1.044,73 (DP = 441,35). Observou-se um aumento significativo no número de óbitos e na taxa de mortalidade ao longo do período, com variação percentual anual de 5,69%. Conclusão: A mortalidade por asma no Brasil continua significativa e em crescimento. Ressaltamos a importância de melhorias no diagnóstico, tratamento e ações de saúde pública voltadas para prevenção e controle.

Palavras-chave: asma, registros de mortalidade, COVID-19, saúde pública.

Introduction

Asthma is a chronic inflammatory disease affecting the airways, triggered by allergic factors from the external environment and resulting from the interaction between genetic predisposition and external elements, leading to hyperresponsiveness of these airways and narrowing of the lumen. Its main characteristics are difficulty breathing, wheezing and tightness in the chest, and short, rapid breaths. Asthma cannot be

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cured, but with the right treatment, symptoms can be significantly reduced and, in some cases, even disappear. That's why it's essential to keep up with regular medical care (1).

The diagnosis of asthma is mainly clinical, made during a doctor's consultation and assessment. However, it is confirmed through physical examination and spirometry, which assesses lung function. Whenever possible, the doctor will order spirometry to confirm the diagnosis and classify the severity of the case. In children up to five years old, the diagnosis is exclusively clinical, due to the difficulty in carrying out functional and complementary tests (2).

Despite the resources available to treat asthma, studies show that around 85% of asthma patients fail to control the disease, mainly due to lack of treatment or non-adherence to the recommended treatment. Another factor that contributes to uncontrolled asthma is the inappropriate use of inhalers, known as 'pumps'. In addition, patients with asthma often have other health conditions, such as rhinitis, gastroesophageal reflux, anxiety, and depression, which make it even more difficult to control the disease. In this sense, emotional control and control of associated comorbidities are important in asthma management. Finally, it is crucial to avoid medications that can trigger allergic reactions or activate asthma's pathophysiological mechanisms, such as some antihypertensives and antiarrhythmics (3).

Asthma represents a serious global health problem, affecting around 300 million people (the number is expected to reach 400 million by 2025) worldwide and resulting in approximately 1,000 deaths every day. Most of these deaths occur in low- and middle-income countries, and most of them are preventable. The disease has a negative impact on work, education, and family life, especially when it affects children. The prevalence of asthma is increasing in many developing countries, and the costs of treating the disease are growing for health systems, communities, and individuals (4).

The prevalence of asthma in the Brazilian population is estimated at around 23.2%, varying regionally between 19.8% and 24.9%. Furthermore, asthma continues to be one of the main causes of hospitalization in the country, with more than 83,000 hospitalizations recorded in 2022 (5).

In 2022, asthma caused 446 deaths in Brazil. Although asthma is a treatable disease, it is still a public health concern due to the large number of hospitalizations and serious complications associated with its inadequate management. Mortality varies between the country's regions, with the South having a higher incidence of deaths, while the North has the lowest rate. The causes of asthma mortality are related to socioeconomic and environmental factors, highlighting the importance of public policies to prevent and control disease (6).

The prevalence of asthma in Rio Grande do Sul is estimated at around 23% of the population, with variations depending on the region and age group. In municipalities such as Porto Alegre, the state capital, the prevalence of asthma hospitalizations reached 1.8% in 2023, with 2.4 cases out of 130.5 general hospitalizations (7).

Regarding mortality in the state of Rio Grande do Sul, respiratory system diseases, including asthma, were responsible for 8.6% of deaths in 2020, being the third leading cause of death, behind only cardiovascular diseases and neoplasms (8).

Given the above, the aim of this article is to analyze asthma mortality in Rio Grande do Sul from 2013 to 2022 and to understand the variation in asthma mortality over the years, including the period of the Covid-19 pandemic.

Methods

This descriptive time series study, with an ecological approach, analyzed asthma mortality in the state of Rio Grande do Sul, Brazil, from January 2013 to December 2022. The study included individuals whose deaths were attributed to asthma, according to the following codes from the 10th International Statistical Classification of Diseases and Related Health Problems (ICD-10): J45: asthma; J450: predominantly allergic asthma; J451: non-allergic asthma; J458: mixed asthma; J459: unspecified asthma.

Mortality data was taken from the Mortality Information System (SIM), and population information was obtained from the 2010 and 2022 censuses,

as well as intercensal estimates for the years 2011 to 2021, provided by the Brazilian Institute of Geography and Statistics (IBGE). Based on this data, we calculated the mortality rates due to asthma.

We also identified the sociodemographic profile of the affected population and the main diagnoses that led to the deaths. We evaluated socio-economic indicators such as the Human Development Index (HDI), the Gini Index, and per capita income, all obtained from the IBGE. The HDI, which ranges from 0 to 1, measures general well-being, with values closer to 1 indicating greater human development (9). The Gini Index, in turn, quantifies income inequality, where values closer to 0 indicate greater equality and values closer to 1 reflect greater inequality (10). These indicators were paired with mortality data for each municipality of residence of the deceased individuals.

To analyze asthma-related mortality, we used the Prais-Winsten generalized linear regression model. This model is widely used in the time series because it considers serial autocorrelation, i.e. the relationship between the values in the series in previous periods (11). We also estimated the annual percentage changes (APC) and analyzed the trends in these changes using joinpoint regression (12). We considered the trends to be increasing when the regression coefficient was positive with $p < 0.05$, decreasing when the coefficient was negative with $p < 0.05$, and stationary when $p > 0.05$.

The entire data extraction and analysis process was carried out in the R programming language (version 4.3.1), using the RStudio development environment. The joinpoint analyses were conducted using the *Joinpoint Regression Program for Windows* software, version 5.0.2.

Results

A total of 1,885 deaths attributed to asthma were recorded in Rio Grande do Sul between 2013 and 2022, predominantly among old people. Deaths were more frequent among women and white individuals, with lower proportions observed among brown and black individuals. Other racial or ethnic categories were minimally represented (Table 1).

TABLE 1 – Sociodemographic characteristics of the individuals who died.

Sociodemographic characteristics	Total (n=1885)
Age in years	68,3±20
Sex Female, (n, %)	1308(69.4)
Race or color**,** (n, %)	
White	1549 (84.4)
Brown	129 (7.0)
Black	153 (8.3)
Other	4 (0.2)
Marital status**,** (n, %)	
Single	429 (25.7)
Married	496 (26.7)
Widowed	597 (34.6)
Legally separated	138 (8.3)
Consensual union	31 (1.8)
Place of death**,** (n, %)	
Household	470 (25.0)
Hospital	1228 (65.2)
Other health establishment	94 (5.0)
Public roads	13 (0.7)
Other	78 (4.1)
Municipalities with the highest number of deaths**,** (n, %)	
Porto Alegre	490 (26)
Caxias do Sul	82 (4.3)
Alvorada	70 (3.7)
Canoas	64 (3.4)
Viamão	54 (2.9)
GINI index	0.5±0.1
HDI	0.7±0.1
Income	1044.7±441.3

HDI: human development index.

Concerning marital status, most of the deaths were by widowed, followed by single and married individuals. Hospital settings accounted for the largest proportion of deaths, although a relevant number also occurred in households and other non-hospital locations (**Table 1**).

Geographically, deaths were concentrated in urban centers, particularly in the state capital and surrounding municipalities. The regions with the highest mortality also showed variation in socioeconomic indicators, including moderate income inequality and high levels of human development. Income levels in these municipalities were relatively low, as reflected in the average earnings reported (Table 1).

Regarding the underlying cause of death, most cases were classified under unspecified asthma, according to the International Classification of Diseases (ICD-10). Specific subtypes, including allergic, mixed, and non-allergic asthma, accounted for only a small portion of the recorded deaths (Table 2).

TABLE 2 – Main causes of death.

ICD with the highest number of deaths, (n,%)	**Total (n=1885)**
J459 - Unspecified asthma	1824 (96.8)
J450 - Predominantly allergic asthma	35 (1.9)
J458 - Mixed asthma	21(1.1)
J451 - Non-allergic asthma	5 (0.3)

The analysis of the time series revealed a general upward trend in both the absolute number of deaths and the mortality rate over the study period. After an initial decline, the data showed a pattern of gradual and sustained increases in the following years (**Figure 1**). Notably, the final year of the series recorded the highest mortality rate (Table 3).

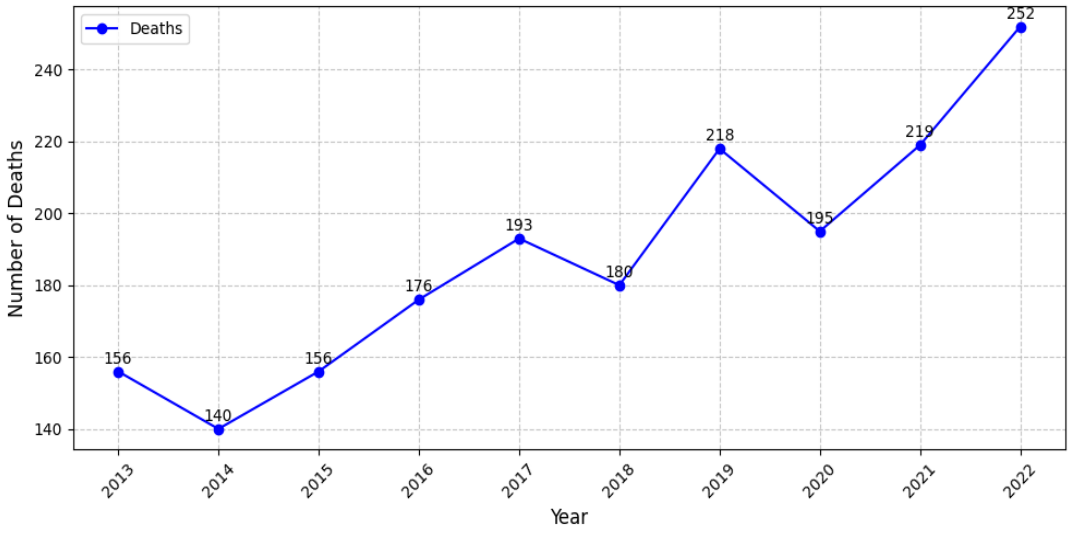

Figure 1 – Annual Mortality Trends from 2013 to 2022.

TABLE 3 – Death rate and time trend.

Year	Deaths	APC* of deaths (%)	Number of inhabitants in RS	Death rate per 100,000 inhabitants	APC of death rate (%)
2013	156	-	11.164.043	1.40	-
2014	140	-10.3	11.199.325	1.25	-10.5
2015	156	11.4	11.228.091	1.39	11.1
2016	176	12.8	11.247.972	1.56	12.6
2017	193	9.7	11.286.500	1.71	9.3
2018	180	-6.7	11.329.605	1.59	-7.1
2019	218	21.1	11.377.239	1.92	20.6
2020	195	-10.5	11.422.973	1.71	-10.9
2021	219	12.3	11.466.630	1.91	11.9
2022	252	15.1	10.882.965	2.32	21.2

APC, annual percentage change; RS, Rio Grande do Sul.

Statistical tests confirmed the non-stationarity of the series. The Prais-Winsten regression model indicated a significant and consistent rise in mortality, supported by a high degree of explanatory power. Additionally, joinpoint regression analysis demonstrated a positive annual percentage change, reinforcing the upward trend observed in asthma-related deaths during the period analyzed (Table 4).

TABLE 4 – Trends in the number of deaths due to asthma.

PERIOD	ESTIMATE (1)	P-VALUE	R^2	APC (%)	P-VALUE
2013 a 2022	10.40	< 0.001	0.97	5.7	0.001

APC, annual percentage change in the number of deaths.

Discussion

This study showed an upward trend in the asthma mortality rate in Rio Grande do Sul from 2013 to 2022, corroborating the findings of other studies carried out in similar periods. The Southern region had the highest asthma death rate in Brazil from 2018 to 2022, as well as an increasing mortality rate in practically all the years analyzed (6). In addition, mortality rates in the South were also the highest in the country from 1980 to 2012 (13).

The COVID-19 pandemic, which began in March 2020 and was present during the period analyzed in our study, contributed to the increase in the number of deaths. COVID-19 has imposed numerous challenges on health systems globally, affecting not only the management of the disease itself but also aggravating pre-existing chronic conditions, such as asthma. Asthmatic individuals, already vulnerable to respiratory complications, have faced additional difficulties during the pandemic. The overload of health services has compromised access to essential medical care, which has resulted in an increase in hospitalizations for asthma (14).

The relationship between the presence of asthma in the clinical picture of a patient who has tested positive for COVID-19, regardless of age group, shows no current evidence to suggest a risk of worsening in people with mild, moderate, and controlled asthma. However, in cases of severe and mainly uncontrolled asthma, the results tend to have a worse outcome (15).

Other evidence suggests that the risk of death from Covid-19 appears to be increased in asthma patients with chronic or recent use of oral corticosteroids. In addition to the disease itself, asthma treatment can also contribute to higher rates of hospitalization in adults, especially for those who use inhaled corticosteroids, which are related to the potentiation of viral replication and delayed elimination of the virus. It has also been suggested that the previous use of more than two oral corticosteroids can significantly increase the chances of needing an ICU and death (16).

A descriptive study on hospitalizations and deaths from asthma in northeastern Brazil during the COVID-19 pandemic observed a reduction in the number of hospital admissions during the analyzed period (14). This may indicate that individuals received more effective preventive and outpatient treatment. However, the authors also identified an increase in death rates, which may be related to more severe cases of asthma, which showed a more lethal response during crises. In addition, this increase in deaths may be associated with the difficulty of accessing emergency services when needed.

A systematic review on the prevalence of asthma among Brazilian regions concluded that prevalence varied from 10.1% to 31.2% between 2003 and 2017, with the South Region presenting the highest rate and the Northeast Region the lowest (17).

Each Brazilian region is heterogeneous and can influence asthma mortality rates. Brazil, with its diverse territory in terms of climate, socioeconomic conditions, lifestyle, and diet, has important factors that affect the risk of developing this respiratory disease. Social, economic, and environmental conditions are determinants of health and any change in one of these aspects contributes to high asthma mortality rates in the country. In addition, there is a lack of regionalized studies in Brazil (18).

The study by Oliveira et al. (19) on mortality from chronic respiratory diseases in Brazil analyzed the time trend of monthly mortality rates from these conditions between 1996 and 2017 and projected this data until 2022. The results indicate a reduction in mortality rates from chronic respiratory diseases in Brazil as a whole. However, the study highlights that asthma is one of the main respiratory diseases contributing to mortality. These diseases mainly affect low-income populations, those with low levels of education, and smokers, as these people are more exposed to risk factors and have less access to health services. Porto Alegre was cited as the capital with the highest percentage of adults who smoke 20 or more cigarettes a day, a factor that aggravates the risk of respiratory diseases.

Several authors have shown that females have a higher burden of disease and a higher incidence of hospitalizations and mortality from asthma than men. One possible association is that women are more prone to exacerbations due to hormonal factors, especially from adolescence onwards (20, 21).

Concerning average income, asthma severity, and mortality, low-income individuals face a series of adverse factors, both in their domestic and professional environments, which can facilitate the manifestations of airflow obstruction present in asthma. In addition, difficulty in accessing adequate treatment is an obstacle to controlling the disease, as it limits access to effective medication and regular treatment, worsening the condition of individuals and increasing the risk of complications and deaths (22).

Finally, we highlight that epidemiological studies provide important input for public health policies aimed at promoting improvements in the management of disease prevention, diagnosis, treatment, and control measures (20).

Despite the methodological rigor adopted, this study presents limitations inherent to the use of secondary data. Mortality rates were calculated based on the 2010 and 2022 demographic censuses, combined with annual intercensal estimates from the IBGE. Although widely used in epidemiological research, these estimates are subject to margins of error, particularly in intercensal years, due to the absence of more frequently collected population data, which may affect the accuracy of annual mortality rates. Furthermore, the potential underreporting of asthma-related deaths in the Mortality Information System, especially in regions with limited access to adequate diagnostic resources or where deficiencies in recording the underlying

cause of death exist, may reflect the operational dynamics of death certificate reporting in the Brazilian public health system, resulting in a possible underestimation of actual mortality rates. In addition to the socioeconomic factors considered, environmental variables, such as air pollution and climate conditions, as well as disparities in access to and quality of healthcare services, may significantly influence mortality outcomes but were not included in the analysis. Lastly, interpreting trends over an extended time series requires caution, as external factors such as public health policies or health emergencies may cause fluctuations that are not fully captured by the statistical models employed. Nevertheless, the use of DATASUS allows for a broad and realistic view of mortality dynamics in Brazil and supports evidence-based public health planning (6, 20).

In addition, it is extremely important to use a standardized means of collecting data for comparative purposes. There is no globally established methodology for accurately measuring asthma prevalence. Existing data is largely isolated by country or region (23).

In conclusion, asthma mortality in Brazil is still significant and shows an upward trend over the years. The highest mortality rate was recorded in 2022, while the lowest was recorded in 2014. Although the disease is controllable and has highly effective treatment, the lack of an accurate diagnosis is a problem that delays proper treatment. It is therefore extremely important to carry out public health prevention, promotion, and control measures.

Notes

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Conflicts of interest disclosure

The authors declare no competing interests relevant to the content of this study.

Authors' contributions

All the authors declare to have made substantial contributions to the conception, or design, or acquisition, or analysis, or interpretation of data; and drafting the work or revising it critically for important intellectual content; and to approve the version to be published.

Availability of data and responsibility for the results

All the authors declare to have had full access to the available data and they assume full responsibility for the integrity of these results.

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