

Lung cancer trend in the state of Rio Grande do Sul, Brazil: ecological study, 2000–2021

Tendência de câncer de pulmão no estado do Rio Grande do Sul: estudo ecológico, 2000–2021

Tendencias de cáncer de pulmón en el estado de Rio Grande do Sul: estudio ecológico, 2000–2021

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Abstract

Introduction: Lung cancer is one of the most common types of cancer worldwide, accounting for 11.4% of all incident cases in 2020, and it is also the leading cause of cancer-related death, with approximately 1.8 million deaths. In Brazil, it stands out among the neoplasms with the greatest impact on public health, especially due to its high mortality. Studies indicate significant regional variations in incidence, particularly in states such as São Paulo, Minas Gerais, and Rio Grande do Sul. Moreover, evidence suggests relevant differences in lung cancer incidence and mortality between men and women, possibly associated with historical patterns of exposure to risk factors such as smoking habit. In this context, analyzing temporal trends in these indicators is essential to understand the dynamics of the disease and to support public health policies for its control.

Objective: To analyze the temporal trend in the incidence rate of hospitalizations and mortality due to lung cancer in the State of Rio Grande do Sul, according to sex, between 2000 and 2021.

Methods: This was an ecological time-series study, with data obtained from national public domain databases. Rates were standardized by age using the direct method and trend analysis was performed using Prais-Winsten Regression. **Results:** According to the data, there was stability in rates of incidence and hospitalizations for lung cancer in men and in total, and an increasing trend in women. A decreasing trend was observed in lung cancer mortality in men and in total, and an increasing trend in mortality was observed in women. There was a decreasing trend in the ratio of all lung cancer coefficients between men and women. **Conclusions:** Stability in lung cancer rates was verified, with a reduction in total mortality, although gender disparities persist. Reducing smoking habit, especially among men, may be a contributing factor. Nonetheless, despite higher rates of lung cancer among men, its considerable increase among women is worrisome.

Keywords: Lung cancer; Lung neoplasms; Time factors; Time-series studies; Ecological studies.

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Resumo

Introdução: O câncer de pulmão é um dos tipos mais comuns de câncer em todo o mundo, representando 11,4% de todos os casos incidentes em 2020, além de constituir a principal causa de morte por câncer, com aproximadamente 1,8 milhão de óbitos. No Brasil, destaca-se entre as neoplasias de maior impacto em saúde pública, especialmente devido à sua elevada mortalidade. Estudos apontam importantes variações regionais na incidência, com destaque para estados como São Paulo, Minas Gerais e Rio Grande do Sul. Além disso, evidências indicam diferenças relevantes na incidência e na mortalidade por câncer de pulmão entre homens e mulheres, possivelmente associadas a padrões históricos de exposição a fatores de risco, como o tabagismo. Nesse contexto, a análise de tendências temporais desses indicadores é fundamental para compreender a dinâmica da doença e subsidiar políticas públicas de controle. **Objetivo:** Analisar a tendência temporal da taxa de incidência de internações e de mortalidade por câncer de pulmão no Estado do Rio Grande do Sul segundo o sexo, entre 2000 e 2021. **Métodos:** Tratou-se de um estudo ecológico de série temporal, com dados obtidos em bases nacionais de domínio público. As taxas foram padronizadas por idade, pelo método direto, e a análise de tendência foi realizada por Regressão de Prais-Winsten. **Resultados:** Os dados revelaram estabilidade nas taxas de incidência e de internações por câncer de pulmão em homens e no total, e tendência crescente em mulheres. Encontrou-se tendência decrescente na mortalidade por câncer de pulmão em homens e no total, e tendência crescente da mortalidade em mulheres. Verificou-se tendência decrescente na razão de todos os coeficientes de câncer de pulmão entre indivíduos do sexo masculino e feminino. **Conclusões:** Demonstrou-se estabilidade nas taxas de câncer de pulmão, com redução na mortalidade total, embora persistam disparidades de gênero. A redução do tabagismo, especialmente entre os homens, pode ser um fator contribuinte. Contudo, apesar das taxas de câncer de pulmão mais elevadas em homens, é preocupante seu evidente crescimento em mulheres.

Palavras-chave: Neoplasia pulmonar. Fatores de tempo. Estudos de séries temporais; Estudos ecológicos.

Resumen

Introducción: El cáncer de pulmón es uno de los tipos de cáncer más comunes en todo el mundo, representando el 11,4% de todos los casos incidentes en 2020, además de constituir la principal causa de muerte por cáncer, con aproximadamente 1,8 millones de fallecimientos. En Brasil, se destaca entre las neoplasias de mayor impacto en la salud pública, especialmente debido a su elevada mortalidad. Los estudios señalan importantes variaciones regionales en la incidencia, con destaque para los estados de São Paulo, Minas Gerais y Rio Grande do Sul. Además, las evidencias indican diferencias relevantes en la incidencia y la mortalidad por cáncer de pulmón entre hombres y mujeres, posiblemente asociadas a patrones históricos de exposición a factores de riesgo, como el tabaquismo. En este contexto, el análisis de las tendencias temporales de estos indicadores resulta fundamental para comprender la dinámica de la enfermedad y orientar políticas públicas de control. **Objetivo:** Analizar la tendencia temporal de la tasa de incidencia, hospitalizaciones y mortalidad por cáncer de pulmón en el Estado de Rio Grande do Sul, según sexo, entre 2000 y 2021. **Métodos:** Este fue un estudio de series temporales ecológicas, con datos obtenidos de bases de datos de dominio público nacional. Las tasas se estandarizaron por edad mediante el método directo y el análisis de tendencias se realizó mediante regresión de Prais-Winsten. **Resultados:** Los datos revelaron estabilidad en las tasas de incidencia y hospitalizaciones por cáncer de pulmón en hombres y en total, y una tendencia creciente en mujeres. Se encontró una tendencia decreciente en la mortalidad por cáncer de pulmón en hombres y en total, y una tendencia creciente en la mortalidad en mujeres. Hubo una tendencia decreciente en la proporción de todos los coeficientes de cáncer de pulmón entre hombres y mujeres. **Conclusiones:** Se demostró estabilidad en las tasas de cáncer de pulmón, con una reducción de la mortalidad total, aunque persisten las disparidades de género. Reducir el tabaquismo, especialmente entre los hombres, puede ser un factor contribuyente. Sin embargo, a pesar de las mayores tasas de cáncer de pulmón en los hombres, el evidente aumento en las mujeres es preocupante.

Palabras clave: Neoplasias pulmonares; Factores de tiempo; Estudios de series temporales; Estudios ecológicos.

INTRODUCTION

Globally, in 2020, approximately 19.3 million new cancer cases and nearly 10 million deaths were recorded.¹ An increase of 47% in cancer cases was predicted by 2040 compared to 2020, reaching 28.4 million.

According to the literature, lung cancer has been considered the second most common cancer diagnosed and the leading cause of cancer mortality in the world in 2020, with an estimated 2.2 million new cases and 1.8 million deaths.¹ Population growth, increased prevalence of risk factors, including smoking habit, unhealthy diets, excess body weight, and sedentary lifestyle, have been mentioned as factors responsible for these estimates.¹

In Brazil, in 2020, 592,212 cases of neoplasms were recorded, of which 40,409 (6.8%) corresponded to lung cancer. As for mortality, there were 259,949 deaths from neoplasms in total. Lung cancer, the main cause of death in the country, totaled 35,160 (13.5%) deaths in 2020.^{1,2}

Regarding the trend of lung cancer cases in Brazil, authors of an epidemiological study using data from the Information Technology Department of the Brazilian Unified Health System (*Departamento de Informática do Sistema Único de Saúde – DATASUS*) showed that, between 2013 and 2020, lung cancer was the most common neoplasm in the country.³ The state of São Paulo presented the highest incidence of lung cancer, followed by Minas Gerais and Rio Grande do Sul. These three states represented 45.5% of all cases registered in the country.³ Furthermore, according to an estimate for the period from 2023 to 2025, lung cancer will be the second most incident type in Rio Grande do Sul.⁴

According to data from the Surveillance System of Chronic Noncommunicable Diseases (NCDs) of the Surveillance System of Risk and Protective Factors for Chronic Diseases by Telephone Survey (*Sistema de Vigilância de Fatores de Risco e Proteção para Doenças Crônicas por Inquérito Telefônico – Vigitel*), of the Brazilian Ministry of Health, there is evidence of the reduction of smoking habit in the state of Rio Grande do Sul.⁵ However, a significant increase in alcohol consumption,⁵ the percentage of obesity, and sedentary lifestyle was observed between the years 2017 and 2021.^{6–10}

Therefore, considering the behavior of risk factors in recent years, in addition to the absence of a historical series contemplating this neoplasm in the State up to the current period, in this study, we aim to analyze the temporal trend of coefficients regarding incidence, hospitalizations, and mortality due to lung cancer in the State of Rio Grande do Sul, according to sex, between 2000 and 2021.

METHODS

An ecological time-series study was carried out, analyzing the rates of incidence, hospitalizations, and mortality due to lung cancer stratified by sex in the State of Rio Grande do Sul, between 2000 and 2021. For the definition of the number of cases, hospitalizations, and deaths from lung cancer, Code C34 of the Tenth Revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10) was considered. Code C34, in its specific definition, refers to malignant neoplasm of bronchi and lung.

Data on lung cancer were obtained from DATASUS via TabNet.³ The number of new cases of lung cancer was obtained in the field “Epidemiology and Morbidity,” in the items “Time until the onset of oncology treatment – Oncology Panel.” Occurrence information was available as of the year 2013. The number of hospitalizations due to lung cancer was obtained in the field “Hospital Morbidity of SUS (SIH/SUS),” collected from 2000 to 2021. The number of deaths was collected in the field “Vital statistics,” item “Mortality – since 1996 by ICD-10,” subitem “General mortality,” comprising the period from 2000 to 2021. For the direct standardization procedure, data were collected with details by age group and sex.

Population data for the period from 2000 to 2021 were obtained from DATASUS/TabNet, in the section “Demographic and Socioeconomic,” in the item “Resident population,” subitem “Study of population estimates by municipality, sex, and age – 2000-2021.” These data were obtained from the estimates made by the Brazilian Institute of Geography and Statistics (IBGE), from which population data were collected for the years 2000 to 2021.

The incidence rates for lung cancer were calculated for each year from 2013 to 2021; and for hospitalizations and mortality, from 2000 to 2021, stratified by sex. To avoid the influence of differences in the age profile of populations in the comparison of coefficients over time, the rates were standardized by age using the direct method, considering the total population of Rio Grande do Sul in 2010 as reference.

The coefficients were expressed every 100 thousand inhabitants per year, and the ratios of the coefficients between men and women were calculated for all outcomes.

The temporal analysis of lung cancer incidence coefficients was performed for the period from 2013 to 2021, and the coefficients of hospitalizations and mortality for the period from 2000 to 2021. Temporal analysis was also performed with the values obtained from the calculation of the ratio between the men and women coefficients in order to verify the occurrence of changes in proportions between sexes during the period.

The temporal trend analysis was carried out by the Prais-Winsten regression method, aiming at controlling first-order autocorrelation. It was analyzed whether the trends of the coefficients showed stabilization, increase, or decrease. Trends whose regressions showed $p > 0.05$ were deemed stationarity; and those with $p \leq 0.05$ were deemed increasing (positive regression coefficient) or decreasing (negative regression coefficient) trends. Statistical analyses were performed using the Stata 12 statistical software.

Regarding ethical aspects, this study was carried out with data available from public information systems without individual identification, as recommended by resolution No. 674 of May 6, 2022, of the National Health Council (CNS).¹¹ According to the Resolution, research using public access information was exempted from approval by the Research Ethics Committee (*Comitê de Ética em Pesquisa – CEP*) and the National Commission of Ethics in Research (*Comissão Nacional de Ética em Pesquisa – CONEP*). Therefore, the project did not need to be submitted to the CEP/CONEP system.¹¹

RESULTS

The results of standardized rates of incidence, hospitalizations, and mortality from lung cancer in the State of Rio Grande do Sul (per 100 thousand inhabitants) are shown in Table 1. The average standardized incidence rate in the period from 2013 to 2021 was 11.6 new cases of lung cancer per 100 thousand inhabitants, ranging from 9.8 in 2017 to the maximum value of 14.4 in 2019. The rates among men were higher than those among women throughout the period, although the difference between sexes decreased.

As for sex, we observed a higher average standardized incidence rate in men in the period, with an average standardized rate of 15.0 new cases of lung cancer every 100 thousand inhabitants per year (ranging from 12.6 in 2017 to 18.2 in 2019); in women, 8.9 new cases of lung cancer were found every 100 thousand inhabitants per year (from 7.3 in 2013 to 11.4 in 2019). According to the temporal trend analysis, we verified stability in lung cancer coefficients, both in the total incidence rate ($p = 0.155$) and in the incidence rate for men ($p = 0.549$); however, there was an increasing trend in the incidence rate for women ($p = 0.020$), as shown in Table 1. Nevertheless, as illustrated in Figure 1, there was a decreasing trend ($p < 0.01$) in the ratio between the incidence coefficients for lung cancer in men and women.

Regarding hospitalizations, in the period from 2000 to 2021, the average standardized rate was 23.2 hospitalizations for lung cancer per 100 thousand inhabitants, with the minimum value observed reaching 10.2 in 2001; and the highest, 29.4 in 2014. In the distribution by sex, higher rates of hospitalizations due to lung cancer were observed in men (mean value 31.7; ranging from 15.4 in 2001 to 39.4 in 2014) compared to women (mean value 16.5; ranging from 6.0 in 2000 to 21.9 in 2017), according to Table 1.

Conversely, in the temporal analysis of the coefficients of total hospitalizations due to lung cancer, we observed a stable trend ($p = 0.175$) as well as the rates of hospitalizations for men ($p = 0.434$). Nonetheless, there was an increasing trend ($p = 0.010$) in hospitalization rates among women (Table 1). In comparison to

sex, there was a decreasing trend ($p < 0.01$) in the ratio between the coefficients of hospitalizations for men in relation to women (Figure 1).

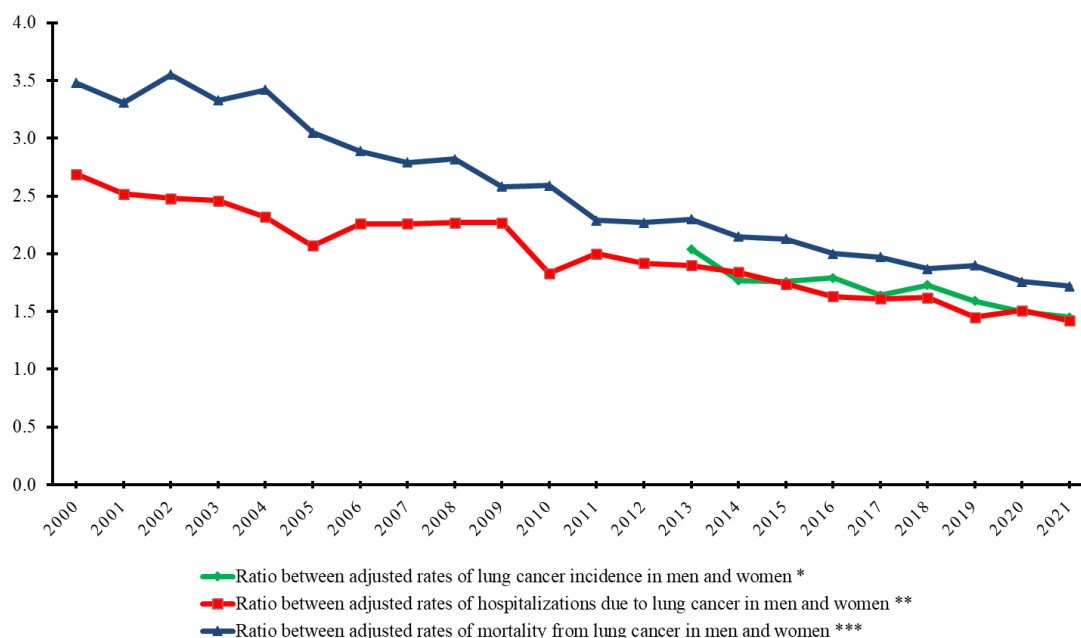
Regarding mortality, from 2000 to 2021, the average standardized rate was 26.4 deaths from lung cancer per 100 thousand inhabitants, ranging from 28.7 in 2000 to 22.5 in 2020. In the period, there was a higher average standardized mortality rate in men, with an average standardized rate of 40.3 deaths from lung cancer/100 thousand inhabitants (ranging from 48.6 in 2000 to 29.7 in 2021) compared to 16.1 deaths from lung cancer/100 thousand inhabitants in women (ranging from 12.7 in 2002 to 18.1 in 2018), as demonstrated in Table 1.

Table 1. Description of the standardized rates of incidence, hospitalization, and mortality from lung cancer in the state of Rio Grande do Sul (per 100 thousand inhabitants).

Year	Incidence rate ^a			Hospitalization rate ^a			Mortality rate ^a		
	Total	M ^b	W ^c	Total	M ^b	W ^c	Total	M ^b	W ^c
2000				10.5	16.1	6.0	28.7	48.6	14.0
2001				10.2	15.4	6.1	27.0	45.3	13.7
2002				16.6	24.6	9.9	26.4	45.1	12.7
2003				19.8	29.6	12.0	27.3	45.7	13.7
2004				22.9	33.5	14.5	27.5	46.4	13.6
2005				22.6	31.7	15.3	28.2	45.9	15.0
2006				24.4	35.3	15.6	27.5	43.8	15.2
2007				24.6	36.0	15.9	28.3	45.1	16.2
2008				23.7	34.6	15.3	28.1	44.7	15.9
2009				26.0	37.9	16.7	27.1	42.0	16.2
2010				26.1	35.3	19.3	27.3	42.3	16.3
2011				24.6	34.2	17.1	26.6	39.7	17.3
2012				24.5	33.6	17.5	26.7	39.4	17.3
2013	10.6	14.9	7.3	25.9	35.3	18.6	26.3	39.2	17.0
2014	11.3	14.9	8.4	29.4	39.4	21.5	26.3	38.0	17.6
2015	10.7	14.1	8.0	27.6	36.4	20.9	26.3	37.9	17.8
2016	10.3	13.7	7.7	27.5	35.2	21.6	25.6	36.0	18.0
2017	9.8	12.6	7.7	27.6	35.2	21.9	24.7	34.6	17.5
2018	12.6	16.5	9.6	26.5	33.9	20.9	24.7	33.7	18.1
2019	14.4	18.2	11.4	25.8	31.2	21.6	24.2	33.3	17.5
2020	12.5	15.4	10.2	22.3	27.6	18.3	22.5	30.0	17.0
2021	12.0	14.6	10.1	20.7	24.9	17.5	22.6	29.7	17.3
Average	11.6	15.0	8.9	23.2	31.7	16.5	26.4	40.3	16.1
Coef.^d	0.29	0.15	0.41	0.49	0.41	0.57	-0.26	-0.85	0.20
95%CI^e	-0.14	-0.42	0.09	-0.24	-0.67	0.15	-0.39	-1.02	0.09
	to	to	to	to	to	to	to	to	to
	0.72	0.72	0.73	1.22	1.50	0.98	-0.12	-0.69	0.30
p^f	0.155	0.549	0.020	0.175	0.434	0.010	0.001	0.000	0.001
Trend	Stat. ^g	Stat. ^g	Incr. ^h	Stat. ^g	Stat. ^g	Incr. ^h	Decr. ⁱ	Decr. ⁱ	Incr. ^h

Source: Prepared by the authors, 2024.

^aAge-standardized rates, expressed per 100 thousand inhabitants; ^bMen; ^cWomen; ^dPrais-Winsten Regression Coefficient; ^e95% Confidence Interval for the Prais-Winsten Coefficient; ^fSignificance value; ^gStationary trend; ^hIncreasing trend; ⁱDecreasing trend.



Caption: * Prais-Winsten: Coef. -0.06 (95%CI -0.07 to -0.04; $p < 0.01$); ** Prais-Winsten: Coef. -0.06 (95%CI -0.06 to -0.05; $p < 0.01$); *** Prais-Winsten: Coef. -0.09 (95%CI -0.10 to -0.08; $p < 0.01$).

Figure 1. State of Rio Grande do Sul: Ratio of adjusted rates of lung cancer between men and women – 2000 to 2021.

As for the temporal analysis, we verified decreasing trends in the overall lung cancer mortality coefficient ($p = 0.01$) and among men ($p < 0.01$). According to the analysis, we observed an increasing trend ($p < 0.01$) in lung cancer mortality rates among women (Table 1). As shown in Figure 1, there was a decreasing trend ($p < 0.01$) in the ratio between mortality coefficients for men and women.

DISCUSSION

In this ecological time-series study, we analyzed the rates of incidence, hospitalizations, and mortality due to lung cancer according to sex in the State of Rio Grande do Sul from 2000 to 2021. According to the data, there was stability in the total rates of incidence and hospitalizations due to lung cancer, showing a reduction in mortality rates. As for sex, we observed that rates of all outcomes were higher in men than in women. Considering the analyses of the trend and ratio of the coefficients among men and women, we verified an increase in the number of cases, hospitalizations, and deaths from lung cancer in women in the analyzed period.

The difference between sexes was also reported in previous studies,^{12–16} whose authors indicated that lung cancer among men is stabilizing or even decreasing, but remains increasing among women. In Brazil, several laws were issued to restrict the possibility of tobacco consumption.^{17,18} In addition, according to the literature, there has been a reduction in smoking habit among men, which could partly explain this finding.^{14,16,19} According to recent data provided by Vigil,⁵ there was a decrease in the frequency of smokers in Brazil from 15.7% in 2006 to 9.5% in 2020, and this reduction was more pronounced among men (from 19.5% in 2006 to 11.7% in 2020) than among women (from 12.4% in 2006 to 7.6% in 2020).

Regarding the availability of findings comparable to those of the present study, according to data on smoking habit in the city of Porto Alegre, capital of Rio Grande do Sul, there was a global reduction in smoking from 20.7% in 2006 to 13.3% in 2020.⁵ Therefore, its reduction was noteworthy in both Brazil

and Rio Grande do Sul, but it should be noted that, despite the decrease, the prevalence of smoking habit remained high among men.

It is worth considering the role of Primary Health Care (PHC) in the implementation of structured strategies for smoking control and in the organization of health care. According to recent evidence, municipal smoking cessation programs had broad coverage, significant adherence, and effectiveness in reducing tobacco consumption, reinforcing the contribution of PHC to tackling nicotine dependence.²⁰ A population-level association was observed between smoking indicators and morbidity and mortality from lung cancer.¹⁵ Although these determinants were not analyzed in the present study, the expansion and consolidation of PHC throughout the observed period may have indirectly contributed to the stabilization of incidence rates and to the reduction of mortality due to lung cancer, especially among men, highlighting the relevance of public health strategies aimed at reducing risk factors at the population level.

It should be noted that, in addition to smoking habit, other physical-chemical and labor-related exposures not analyzed in the present study, such as air pollution or exposure to asbestos, radon, arsenic, chromium, nickel, hydrocarbons, and silica, are also important risk factors for the development of lung cancer and may have contributed to the observed outcomes.^{15,21–25}

The present study has some limitations. The first to be considered is inherent in the ecological design. Ecological studies have intrinsic limitations, such as ecological fallacy, the possibility of issues related to undernotification, representativeness, and classification.²⁶ The data source was restricted to what was made available in the official agencies at the time of collection. Data were collected on indicators of lung cancer (new cases, hospitalizations, and deaths) notified at DATASUS. Therefore, errors in the notification of indicators by the municipalities or even updates made after data collection may have directly influenced the calculated coefficients. However, regarding the Hospital Information System (*Sistema de Informação Hospitalar* – SIH/SUS), it is known that it was created in the Ministry of Social Security and Social Assistance with accounting intention, thus minimizing the errors of notification.²⁷

Another specific limitation was related to representativeness. The SIH/SUS was restricted to information about hospitalizations carried out by the SUS.²⁸ However, according to data from IBGE, about 70% of the Brazilian population did not have access to supplementary health and uses the Brazilian Unified Health System (SUS).²⁸ Another factor worth highlighting was the occurrence of readmission cases of the same individuals: the data did not allow acknowledging this distinction, but in the present analysis these cases could overestimate the coefficients, reinforcing the results. The possibility of classification error was remote, because it was performed in a hospital environment. Thus, in addition to better diagnostic conditions, Hospital Admission Authorizations (*Autorizações de Internação Hospitalar* – AIHs) have been periodically audited by the SUS together with the effort of the Ministry of Health to generate data for the evaluation of reliable results.²⁹ The Mortality Information System (*Sistema de Informação sobre Mortalidade* – SIM) has provided information on deaths since 1979. Furthermore, the literature has pointed to the continuous improvement in the accuracy of mortality data in Brazil over time, although it has shown great regional variations.^{30,31}

The definition of the cause of death may be impaired by the presence of ill-defined causes. In this sense, the expansion and improvement of the Death Verification Services (*Serviços de Verificação de Óbito* – SVO) have also contributed to the improvement of the classification of causes of death, especially those classified as ill-defined.³¹ In Brazil, deaths classified as ill-defined decreased; the proportion of deaths from ill-defined causes was higher than 20% in the 1980s, decreasing to approximately 18% in the 1990s, and reaching 5.7% in 2015. It is also emphasized that in the Southern region of the country, it

reached only 3.4% of deaths, mainly due to the efforts of professionals and system managers at all levels of performance, improving the quality of information.³¹

Finally, in the general context of the present study, we highlight that the analysis was conducted with a robust and adequate method; the historical series comprises a long period; the standardization of the coefficients eliminated the differences in age structure, and the stratification by sex was also carried out, allowing for comparisons.

CONCLUSION

In this study, we showed an updated historical series of lung cancer coefficients in the state of Rio Grande do Sul. We verified stability in lung cancer rates, with a reduction in total mortality. Smoking habit reduction, especially among men, may have been one of the contributing factors. Although several regulatory measures have been implemented in Brazil and the data have pointed to a reduction in smoking habit, the issue is still worrisome due to the evident increase in lung cancer coefficients in women. Thus, knowledge of the temporal behavior of lung cancer should guide public management, focusing on women's health. Authors of future studies should analyze the causal relationship of smoking habit and other risk factors in the development of lung cancer.

CONFLICT OF INTERESTS

Nothing to declare.

AUTHORS' CONTRIBUTIONS

JCJ: Conceptualization, Data curation, Formal analysis, Writing – original draft. JSDC: Conceptualization, Data curation, Formal analysis, Writing – original draft. CHEO: Conceptualization, Data curation, Formal analysis. OASF: Conceptualization, Data curation, Formal analysis. VMVP: Conceptualization, Data curation, Formal analysis, Writing – review & editing.

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