# Temporal Trend of Mortality by Oral Cancer in Brazil, 1997-2023

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*Tendência Temporal da Mortalidade por Câncer de Boca no Brasil, 1997-2023*

Tendencia Temporal de la Mortalidad por Cáncer de Boca en el Brasil, 1997-2023

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ABSTRACT

**Introduction:** Oral cancer is a public health challenge, and the analysis of its mortality trends is essential to guide prevention and control strategies. **Objective:** To describe the temporal and regional trends in oral cancer mortality rates in Brazil between 1997 and 2023. **Method:** Descriptive time series study using data from the Mortality Information System and the "*Instituto Brasileiro de Geografia e Estatística (IBGE)*". Deaths occurring between 1997 and 2023, classified according to codes C00 to C10 of the 10th Revision of the International Classification of Diseases (ICD-10) were included. The variables analyzed were sex, age, region, Federative Unit, education level, and race/ethnicity. The trend was analyzed using Prais-Winsten regression, estimating the annual percentage change (APC) with a 95% confidence interval. **Results:** A total of 133,319 deaths were recorded. The national trend was stationary (APC -0.60; *p*=0.507). Mortality was predominant among men (78.3%) and individuals over 60 years old (45.1%). The Southeast and the South regions showed decreasing trends, while the North and Northeast regions increased significantly, with emphasis in the states of Acre (APC 4.73) and Maranhão (APC 2.68). The oropharynx (C10) was the most common site (32%), followed by tongue (C02) and unspecified parts of the mouth (C06). Individuals with 12 or more years of education showed a stationary trend (APC 0.43; *p*=0.376), while the other categories exhibited rising trends, especially those with one to three years of education (APC 8.11; *p*=0.021). **Conclusion:** A predominantly stationary trend was observed during the period analyzed, declining in more developed regions and growing in less developed ones.

**Key words:** Mouth Neoplasms/mortality; Mortality/trends; Health Information Systems; Time Series Studies.

RESUMO

**Introdução:** O câncer de boca é um desafio à saúde pública, e a análise de suas tendências de mortalidade é essencial para orientar estratégias de prevenção e controle. **Objetivo:** Descrever as tendências temporais e regionais das taxas de mortalidade por câncer de boca no Brasil entre 1997 e 2023. **Método:** Estudo descritivo de séries temporais com dados do Sistema de Informações sobre Mortalidade e do Instituto Brasileiro de Geografia e Estatística. Incluíram-se óbitos entre 1997 e 2023, classificados nos códigos C00 a C10 da CID-10. As variáveis analisadas foram sexo, idade, Região, Unidade Federativa, escolaridade e cor/etnia. A tendência foi avaliada por regressão de Prais-Winsten, estimando a variação percentual anual (APC) com intervalo de confiança de 95%. **Resultados:** Foram registrados 133.319 óbitos. A tendência nacional foi estacionária (APC -0,60; *p*=0,507). A mortalidade predominou entre homens (78,3%) e maiores de 60 anos (45,1%). As Regiões Sudeste e Sul apresentaram tendência decrescente, enquanto Norte e Nordeste mostraram crescimento, com destaque para Acre (APC 4,73) e Maranhão (APC 2,68). A orofaringe (C10) foi o sítio mais comum (32%), seguida da língua (C02) e boca não especificada (C06). Indivíduos com 12 ou mais anos de escolaridade apresentaram tendência estacionária (APC 0,43; *p*=0,376), enquanto as demais categorias tiveram tendências crescentes, especialmente com um a três anos de estudo (APC 8,11; *p*=0,021). **Conclusão:** Observou-se predominância de tendência estacionária no período analisado, com queda nas Regiões mais desenvolvidas e crescimento nas menos desenvolvidas.

**Palavras-chave:** Neoplasias Bucais/mortalidade; Mortalidade/tendências; Sistemas de Informação em Saúde; Estudos de Séries Temporais.

RESUMEN

**Introducción:** El cáncer de boca representa un desafío para la salud pública, y el análisis de sus tendencias de mortalidad es esencial para orientar estrategias de prevención y control. **Objetivo:** Describir las tendencias temporales y regionales de las tasas de mortalidad por cáncer de boca en el Brasil entre 1997 y 2023. **Método:** Estudio descriptivo de series de tiempo con datos del Sistema de Información sobre Mortalidad y del Instituto Brasileño de Geografía y Estadística. Se incluyeron los óbitos ocurridos entre 1997 y 2023, clasificados según los códigos C00 a C10 de la Clasificación Internacional de Enfermedades, 10ª revisión (CIE-10). Las variables analizadas fueron sexo, edad, región, unidad federativa, nivel de educación y raza/etnia. La tendencia fue evaluada mediante regresión de Prais-Winsten, estimando la variación porcentual anual (VPA) con un intervalo de confianza del 95%. **Resultados:** Se registraron 133 319 muertes. La tendencia nacional fue estacionaria (VPA -0,60; *p*=0,507). La mortalidad predominó en hombres (78,3%) y en personas mayores de 60 años (45,1%). Las regiones Sudeste y Sur presentaron tendencia decreciente, mientras que Norte y Nordeste mostraron un crecimiento, destacándose Acre (VPA 4,73) y Maranhão (VPA 2,68). La orofaringe (C10) fue el sitio más común (32%), seguida de la lengua (C02) y boca no especificada (C06). Los individuos con 12 o más años de educación presentaron una tendencia estacionaria (VPA 0,43; *p*=0,376), mientras que las demás categorías mostraron tendencias crecientes, especialmente aquellos con uno a tres años de educación (VPA 8,11; *p*=0,021). **Conclusión:** Se observó una predominancia de tendencia estacionaria en el período analizado, con disminución en las regiones más desarrolladas y aumento en las menos desarrolladas.

**Palabras clave:** Neoplasias de la Boca/mortalidad; Mortalidad/tendencias; Sistemas de Información en Salud; Estudios de Series Temporales.

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## INTRODUCTION

Oral cancer encompasses a variety of neoplasms affecting lips, oral cavity and oropharynx[1]. Its incidence is higher in high and middle-income countries, particularly Oceania, Asia and Europe. According to Globocan[2] , it is estimated that 17,492 new cases will occur in Brazil in 2025 for both sexes, the incidence in men is 3.69-fold higher than in women, and mortality was estimated in 8,625 deaths for the same year.

Smoking, human papillomavirus infection and alcohol use are the leading risk factors for this neoplasm[3]. Although alcohol is frequently associated with oral cancer, there are no clear evidences that alcohol is an isolated promoting agent because its role is more related to the potentialization of carcinogenic effects of other factors as smoking[4,5]. Smoking, on its turn, directly exposes oral mucosa to carcinogenic agents, compromising its integrity and favoring the appearance of neoplastic lesions[5]. Human papillomavirus infections, specifically by oncogenic types, play a key part on the genesis of oropharynx neoplasms[6].

Mortality rates and oral cancer survival are closely related to the stage at diagnosis, agility and efficacy of the treatment, in addition to individual factors. Most of the cases occurs in men, and younger patients usually have better prognosis[7]. The disease clinical stage and the quality of the therapeutic significantly influence the outcome, directly affecting survival rates. Comorbidities and cardiovascular diseases and diabetes *mellitus* in older adults increase the vulnerability and risk of complications[2].

Oral cancer is a significant public health challenge, affecting the quality of life, esthetics, speech, feeding in addition to emotional impacts[8]. Given the relevance of this pathology, it is crucial that health entities and institutions concentrate efforts in control and prevention. In Brazil, it is the eighth most common and according to the National Cancer Institute (INCA), 15,100 new cases are estimated annually for the triennium 2023-2025[9].

The temporal analysis of mortality rates by neoplasms is an essential tool for public health planning because it favors the understanding of how this outcome evolves in years and in different populational contexts. It is possible to identify patterns while analyzing these variations, evaluate the efficacy of public policies already implemented and anticipate future scenarios, which contribute to the formulation of better strategies of prevention, early diagnosis and treatment. In addition, this type of monitoring allows to adjust control actions to the epidemiologic reality of each region, considering the persistence or modification of the conditions that influence the occurrence of the disease[10].

The objective of this study is to describe the temporal and regional trends of mortality rates by oral cancer between 1997 and 2023, evaluating the time variations in different country regions. Given the elevated incidence and social impact of oral cancer, it is paramount to analyze continuously these trends to monitor the evolution of the disease and guide effective strategies of control and prevention[11].

## METHOD

Descriptive study analyzing the time series for the period 1997-2023 and the mortality by oral cancer in Brazil, its regions and federative units. Raw data of deaths by oral cancer classified according to codes C00 to C10 of 10$^{th}$ International Statistical Classification of Diseases and Related Health Problems (ICD-10)[12], encompassing malignant neoplasms of lip (C00), base of the tongue (C01), tongue (C02), gingiva (C03), floor of the mouth (C04), palate (C05), other and unspecified parts of mouth (C06), parotid gland (C07), other and unspecified major salivary glands (C08), amygdala (C09) and oropharynx (C10). Deaths from 20 years of age were considered since oral cancer in younger than 20 years old individuals is rare. Deaths were classified in 16 age groups with 5-year intervals, initiating in 20-24 years until 75-79 years, in addition to the category of 80 years or older. The study followed the guidelines of Reporting of Studies Conducted using Observational Routinely-collected health Data[13], specific for secondary data-based studies.

The following categorical variables were analyzed: regions (North, Northeast, Midwest, Southeast, South), federative unit (Acre, Alagoas, Amazonas, Bahia, Ceará, Federal District, Espírito Santo, Goiás, Maranhão, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Pará, Paraíba, Paraná, Pernambuco, Piauí, Rio de Janeiro, Rio Grande do Norte, Rio Grande do Sul, Rondônia, Roraima, Santa Catarina, São Paulo, Sergipe, Tocantins), year of death (1997 to 2023), age range (20 to 24, 25 to 29, 30 to 34, 35 to 39, 40 to 44, 45 to 49, 50 to 54, 55 to 59, 60 to 64, 65 to 69, 70 to 74, 75 to 79, 80 or older), sex (male and female), color/ethnicity (White, Black, Yellow, Brown and Indigenous) and education (illiterate, 1 to 3 years, 4 to 7 years, 8 to 11 years, 12 years or more).

Quantitative variables included number of deaths by oral cancer and populational data. Raw mortality rates were calculated between the number of deaths and size of the resident population adjusted to a base of 100 thousand inhabitants. For comparison purposes, raw mortality rates were standardized to the world population of 1960 by the direct method. The software CorelDRAW[14] (version 22.1.523) was adopted to depict the distribution of

mortality by oral cancer in regions and federative units.

Mortality data were obtained from the mortality information system (SIM) of the Ministry of Health, accessible through the computer system of the National Health System (DATASUS)[15]. The tool TABNET[16] was utilized to extract the data selecting the variables of interest for 1997-2023. The censuses of 1991, 2000, 2010 and 2022 of the "*Instituto Brasileiro de Geografia e Estatística (IBGE)*[17] and estimates of the resident population of the regions in the period analyzed were the source of the population data.

Microsoft Excel® was utilized to organize and analyze the data, the quantitative variables were expressed in absolute and relative frequencies.

The Prais-Winsten linear generalized regression method was adopted to evaluate the temporal trend of the mortality rates proposed by Antunes and Cardoso[10]. The logarithm of the rates was the dependent variable and the years of the period analyzed was the independent variable to estimate the annual percent change (APC), considering the total number of years minus one. The formula utilized to calculate the APC was: APC = [10^b – 1] × 100%, being "b" the coefficient of regression, representing the annual variation. The confidence interval of 95% (CI95%) was obtained by the expression: CI95% = [10^ (b ± t × se) – 1] × 100%, where "se" corresponds to the standard error of the coefficient and "t" the critical value of the distribution *t* of Student, $p < 0.05$ was considered statistically significant. The trend was classified as rising when b>0, decreasing when b<0 and stationary when there was no statistical significance. Additionally, Poisson's regression with adjustment for super-dispersion through the negative binomial model was adopted to model the total number of deaths according to the independent variables (year, sex and age-ranges). Rate ratios (RR) and respective CI95% were estimated. The software R[18] (version 5.1.513) was utilized for the analyzes and the data were previously tabulated in Microsoft Excel® 2016 spreadsheets.

The ethical analysis of the study by an Ethical Committee was waived because only public, deidentified and secondary data of the Ministry of Health were utilized in compliance with Directive 466 of December 12, 2016[19] and Law 12,527 of November 18, 2011[20].

## RESULTS

133,319 deaths by oral cancer have been recorded in Brazil in the period 1997–2023. The mean national mortality rate was 2.94 deaths per 100 thousand inhabitants with regional variations. The overall trend was stationary in the period (APC -0.06; CI95% -0.25;0.12; $p$=0.507) (Table 1).

More than half of the deaths occurred in the Southeast region (51.7%) and decreasing trend (APC -0.46; CI95% -0.60;-0.32; $p$<0.001), mainly in the states of São Paulo (APC -0.71; $p$<0.001) and Rio de Janeiro (APC -1.17; $p$<0.001), similar to the observed in the South region (APC -0.36; CI95% -0.52;-0.21; $p$<0.001), with significant declines in the states of Paraná (APC -0.52; $p$<0.001) and Rio Grande do Sul (APC -0.35; $p$=0.001).

The Northeast region presented rising trend (APC 1.07; CI95% 0.56;1.58; $p$<0.001) with significant increases in all states. Significant increases were also registered in the North region (APC 0.73; CI95% 0.47;0.98; $p$<0.001), mainly in Acre (APC 4.73; $p$<0.001) and in Tocantins (APC 1.99; $p$<0.001). The Midwest region exhibited stationary trend (APC 0.34; $p$=0.081), without statistically significant variations in the states, except Goiás, which presented rising trend (APC 0.55; $p$=0.024).

Time series modeling revealed that 19 states presented rising trend in the period investigated, including seven states of the North region, nine in the Northeast, two in the Southeast and one in the Midwest (Figure 1). Four states presented decreasing trend, two in the Southeast and two in the South. The other states were stationary. The highest rising trend was observed in Acre (APC 4.73), while the highest decreasing trend was registered in Rio de Janeiro (APC -1.17), both statistically significant.

Malignant neoplasm of oropharynx (C10) was the most prevalent among the anatomic sites, accounting for 32.01% of the deaths followed by C02 (other and unspecified parts of the tongue) and C06 (other and unspecified parts of the mouth) (Table 2). The majority of the sites analyzed presented rising trend, standing out floor of the mouth (C04) with the highest increase (APC 1.11; $p$<0.001). In counterpart, decreasing trend was observed for the neoplasms of the amygdala (C09) (APC -0.35; $p$=0.007).

Mortality was higher in men (78.39%), with mean rate of 6.33 deaths per 100 thousand inhabitants and rising trend (APC 0.54; $p$<0.001) (Table 3), similar pattern for females (APC 0.86; $p$<0.001). Decreasing trends were observed in adults in the age range of 0-59 years, with highest decline in 40-44 years (APC -0.93; $p$<0.001) and 35-39 years (APC -0.79; $p$<0.001). Rising trend was noticed among 60-79 years older adults (APC 0.17; $p$=0.031) and stationary trend in the age range of 80 years or older (APC 0.14; $p$=0.386).

Individuals with 12 years or more of education presented stationary trend (APC 0.43; $p$=0.376), while all the other categories exhibited rising trend, standing out those with one to three years of education (APC 8.11; $p$=0.021). There was rising trend in the stratification per sex/ethnicity for all the categories, except for Yellow

**Table 1.** Number and percent of deaths, mean rate per 100 thousand inhabitants and trends of mortality by oral cancer per regions and Federative Units. Brazil, 1997-2023

| Regions and Federative Units | Deaths | | Mean raw rate of mortality | APC (CI95%) | *p* | Trend |
|---|---|---|---|---|---|---|
| | N | % | | | | |
| **North** | **4,527** | **3.40** | **1.19** | **0.73 (0.47;0.98)** | **<0.001** | **Rising** |
| Rondônia | 565 | 0.42 | 1.50 | 1.00 (0.38;1.61) | 0.004 | Rising |
| Acre | 145 | 0.11 | 0.78 | 4.73 (2.42;7.08) | <0.001 | Rising |
| Amazonas | 957 | 0.72 | 1.15 | 0.49 (0.13;0.86) | 0.014 | Rising |
| Roraima | 144 | 0.11 | 1.08 | 1.90 (0.87;2.94) | 0.001 | Rising |
| Pará | 2,108 | 1.58 | 1.20 | 0.48 (0.15;0.81) | 0.009 | Rising |
| Amapá | 195 | 0.15 | 1.20 | 0.95 (0.08;1.84) | 0.043 | Rising |
| Tocantins | 413 | 0.31 | 1.22 | 1.99 (1.02;2.97) | <0.001 | Rising |
| **Northeast** | **28,483** | **21.36** | **2.31** | **1.07 (0.56;1.58)** | **<0.001** | **Rising** |
| Maranhão | 1,365 | 1.02 | 0.90 | 2.68 (1.93;3.45) | <0.001 | Rising |
| Piauí | 1,244 | 0.93 | 1.69 | 1.96 (0.99;2.94) | 0.001 | Rising |
| Ceará | 4,721 | 3.54 | 2.37 | 1.14 (0.70;1.58) | <0.001 | Rising |
| Rio Grande do Norte | 2,059 | 1.54 | 2.74 | 1.18 (0.45;1.91) | 0.004 | Rising |
| Paraíba | 2,400 | 1.80 | 2.68 | 1.69 (0.32;3.08) | 0.023 | Rising |
| Pernambuco | 5,707 | 4.28 | 2.81 | 0.51 (0.17;0.84) | 0.006 | Rising |
| Alagoas | 1,503 | 1.13 | 2.14 | 1.89 (1.33;2.46) | <0.001 | Rising |
| Sergipe | 1,321 | 0.99 | 2.68 | 1.78 (0.18;3.40) | 0.039 | Rising |
| Bahia | 8,163 | 6.12 | 2.52 | 0.68 (0.48;0.87) | <0.001 | Rising |
| **Southeast** | **68,941** | **51.71** | **3.59** | **-0.46 (-0.60;-0.32)** | **<0.001** | **Decreasing** |
| Minas Gerais | 14,041 | 10.53 | 2.95 | 0.77 (0.56;0.98) | <0.001 | Rising |
| Espírito Santo | 3,475 | 2.61 | 3.90 | 0.52 (0.21;0.83) | 0.003 | Rising |
| Rio de Janeiro | 15,227 | 11.42 | 4.09 | -1.17 (-1.45;-0.89) | <0.001 | Decreasing |
| São Paulo | 36,198 | 27.15 | 3.66 | -0.71 (-0.86;-0.56) | <0.001 | Decreasing |
| **South** | **23,282** | **17.46** | **3.50** | **-0.36 (-0.52;-0.21)** | **<0.001** | **Decreasing** |
| Paraná | 9,053 | 6.79 | 3.62 | -0.52 (-0.70;-0.35) | <0.001 | Decreasing |
| Santa Catarina | 4,745 | 3.56 | 2.84 | -0.14 (-0.36;0.08) | 0.221 | Stationary |
| Rio Grande do Sul | 9,484 | 7.11 | 3.80 | -0.35 (-0.53;-0.17) | 0.001 | Decreasing |
| **Midwest** | **8,086** | **6.07** | **2.26** | **0.34 (-0.03;0.70)** | **0.081** | **Stationary** |
| Mato Grosso do Sul | 1,606 | 1.20 | 2.68 | 0.02 (-0.27;0.30) | 0.912 | Stationary |
| Mato Grosso | 1,476 | 1.11 | 1.89 | 0.59 (-0.12;1.31) | 0.114 | Stationary |
| Goiás | 3,530 | 2.65 | 2.27 | 0.55 (0.10;1.01) | 0.024 | Rising |
| Federal District | 1,474 | 1.11 | 2.29 | 0.06 (-0.47;0.59) | 0.833 | Stationary |

**Captions:** APC = annual percentage change; CI = confidence interval.

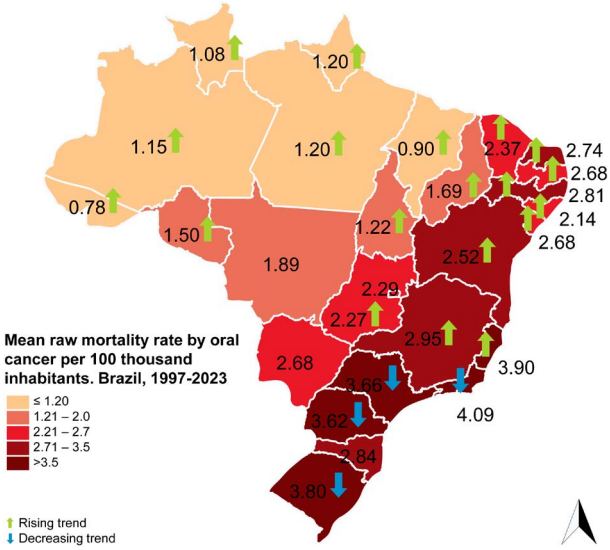


**Figure 1**. Plot of the spatial distribution of mean rates of mortality by oral cancer per 100 thousand inhabitants. Brazil, 1997-2023
**Source**: The authors based on SIM[15].

individuals who presented stationary trend (APC -0.90; $p$=0.526). Brown individuals presented the greatest rise (APC 3.25; $p$<0.001).

After adjusted to age, year and sex, it has been observed that individuals aged 40-59 years presented rate of 10.96 (CI95% 6.89;17.46) compared with the reference age-range (20 to 39 years). This ratio increased to 21.94 (CI95% 13.78;34.93) in the 60-79 aged group and to 110.66 (CI95% 69.50;176.20) for those aged 80 years or older. Men presented rate ratio 1.65-fold higher (CI95% 1.19;2.29) than females. The variable year did not show statistically significant association with the outcome (RR 0.99; CI95% 0.97;1.01).

## DISCUSSION

The analysis of mortality trends along more than two decades revealed overall stationary trend but with expressive heterogeneity among regions, states, age ranges, education levels and color/ethnicity, which reinforces the epidemiologic complexity of oral cancer and its interactions with health inequalities.

The mortality by sex kept stable with predominance in men, reflecting behavioral differences of searching for health services and exposure to disease's risk factors[21,22]. This discrepancy can be explained because, usually, men seek preventive dental care less than women, which contributes to initial delayed detection of oral lesions[23].

Mortality increased among older adults (≥60 years) and declined in individuals until 59 years old consistent with recognizing age as risk factor for several types of cancer[24]. Indigenous, Browns and Blacks presented high increases, suggesting potential inequalities of access to diagnosis and treatment[25]. Rising mortality trend among individuals with low education was observed, as they present significantly great risk for head and neck cancers, especially oropharynx and oral cavity[26].

Analysis by anatomic site indicated oropharynx (C10) as the most prevalent site, although with stationary trend. Greatest declines were observed for neoplasms of the gingiva (C03), amygdala (C09) and unspecified parts

**Table 2**. Number and percent of deaths, mean rate per 100 thousand inhabitants and trends of the mortality rates by oral cancer per anatomic site. Brazil, 1997-2023

| Site | Deaths | | Mean raw rate of mortality | APC (CI95%) | *p* | Trend |
|---|---|---|---|---|---|---|
| | N | % | | | | |
| C00 – Lip | 1,488 | 1.12 | 0.04 | 0.51 (0.13;0.89) | 0.014 | Rising |
| C01 – Base of the tongue | 11,128 | 8.35 | 0.32 | 0.66 (0.08;1.25) | 0.034 | Rising |
| C02 – Other parts of the tongue | 26,599 | 19.95 | 0.77 | 0.82 (0.69;0.95) | <0.001 | Rising |
| C03 – Gingiva | 1,135 | 0.85 | 0.03 | -0.28 (-0.60;0.04) | 0.102 | Stationary |
| C04 – Floor of the mouth | 5,140 | 3.86 | 0.15 | 1.11 (0.87;1.35) | <0.001 | Rising |
| C05 – Palate | 6,381 | 4.79 | 0.19 | 0.62 (0.40;0.83) | <0.001 | Rising |
| C06 – Other parts of the mouth | 26,555 | 19.92 | 0.78 | 0.14 (-0.16;0.44) | 0.383 | Stationary |
| C07 – Parotid gland | 6,167 | 4.63 | 0.18 | 0.73 (0.55;0.91) | <0.001 | Rising |
| C08 – Other glands | 2,089 | 1.57 | 0.06 | 1.05 (0.67;1.43) | <0.001 | Rising |
| C09 – Amygdala | 3,965 | 2.97 | 0.12 | -0.35 (-0.57;-0.12) | 0.007 | Decreasing |
| C10 – Oropharynx | 42,672 | 32.01 | 1.24 | 0.70 (0.58;0.82) | <0.001 | Rising |

**Captions:** APC = annual percentage change; CI = confidence interval.

**Table 3.** Number and percent of deaths, mean rate per 100 thousand inhabitants and trends of mortality by oral cancer according to sex, age-range, education, color/ethnicity. Brazil, 1997-2023

| Variables | Deaths | | Raw mortality rate | APC (CI95%) | *p* | Trend |
|---|---|---|---|---|---|---|
| | N | % | | | | |
| **Raw rate** | 133,319 | 100 | 2.94 | -0.06 (-0.25;0.12) | 0.507 | Stationary |
| **Sex** | | | | | | |
| Female | 28,813 | 21.61 | 1.60 | 0.86 (0.75;0.98) | <0.001 | Rising |
| Male | 104,497 | 78.39 | 6.33 | 0.54 (0.41;0.67) | <0.001 | Rising |
| **Age range** | | | | | | |
| **Young adult** | **3,430** | **2.57** | **0.20** | **-0.18 (-0.33;-0.02)** | **0.032** | **Decreasing** |
| 20 to 24 years | 221 | 0.17 | 0.05 | 1.38 (0.71;2.05) | <0.001 | Rising |
| 25 to 29 years | 396 | 0.30 | 0.09 | 0.54 (-0.01;1.09) | 0.064 | Stationary |
| 30 to 34 years | 719 | 0.54 | 0.17 | -0.02 (-0.44;0.40) | 0.911 | Stationary |
| 35 to 39 years | 2,094 | 1.57 | 0.55 | -0.79 (-0.90;-0.67) | <0.001 | Decreasing |
| **Adult** | **53,397** | **40.05** | **4.74** | **-0.23 (-0.50;0.05)** | **0.115** | **Stationary** |
| 40 to 44 years | 5,617 | 4.21 | 1.66 | -0.93 (-1.09;-0.78) | <0.001 | Decreasing |
| 45 to 49 years | 10,979 | 8.24 | 3.70 | -0.78 (-1.13;-0.43) | <0.001 | Decreasing |
| 50 to 54 years | 16,759 | 12.57 | 6.48 | -0.39 (-0.70;-0.08) | 0.022 | Decreasing |
| 55 to 59 years | 20,042 | 15.03 | 9.11 | -0.03 (-0.27;0.21) | 0.811 | Stationary |
| **Younger older** | **60,232** | **45.18** | **12.08** | **0.17 (0.02;0.32)** | **0.031** | **Rising** |
| 60 to 64 years | 19,628 | 14.72 | 10.77 | 0.17 (0.01;0.32) | 0.042 | Rising |
| 65 to 69 years | 16,856 | 12.64 | 11.89 | 0.27 (0.10;0.44) | 0.004 | Rising |
| 70 to 74 years | 13,312 | 9.99 | 12.76 | 0.12 (0.01;0.22) | 0.038 | Rising |
| 75 to 79 years | 10,436 | 7.83 | 14.84 | 0.01 (-0.24;0.27) | 0.924 | Stationary |
| **Older 80+ (long-lived)** | **16,260** | **12.20** | **20.18** | **0.14 (-0.17;0.45)** | **0.386** | **Stationary** |
| **Education** | | | | | | |
| None | 18,031 | 18.26 | 0.52 | 0.57 (0.40;0.75) | <0.001 | Rising |
| 1 to 3 years | 29,756 | 30.14 | 0.84 | 8.11 (1.58;15.05) | 0.021 | Rising |
| 4 to 7 years | 28,052 | 28.42 | 0.79 | 7.53 (1.83;13.54) | 0.015 | Rising |
| 8 to 11 years | 16,262 | 16.47 | 0.44 | 8.40 (3.57;13.47) | 0.002 | Rising |
| 12 years and more | 6,619 | 6.70 | 0.20 | 0.43 (-0.51;1.39) | 0.376 | Stationary |
| **Color/Ethnicity** | | | | | | |
| White | 72,163 | 57.80 | 2.96 | 1.64 (1.13;2.14) | <0.001 | Rising |
| Black | 11,002 | 8.81 | 2.98 | 1.37 (0.52;2.23) | 0.004 | Rising |
| Yellow | 696 | 0.56 | 2.64 | -0.90 (-3.61;1.88) | 0.526 | Stationary |
| Brown | 40,845 | 32.71 | 1.92 | 3.25 (1.79;4.72) | <0.001 | Rising |
| Indigenous | 152 | 0.12 | 0.65 | 2.08 (1.00;3.18) | 0.001 | Rising |

**Captions:** APC = annual percentage change; CI = confidence interval.

of the mouth (C06), suggesting a possible impact of the actions of prevention, screening and treatment offered by health services. Despite the advances of specialized services and less invasive interventions[27], the findings suggest that these advances have not translated yet into significant reduction of mortality at these sites.

Several studies about time series of oral cancer in Brazil confirm the regional heterogeneity and inequalities of access to health services[28-30]. Perea et al. identified the national stationary trend of mortality by oral cancer and pharynx (2002-2013), increasing in the Northeast and declining in the Southeast, emphasizing the necessity of policies focused to the North and Northeast regions[28]. Atty et al.[29] observed a general drop of mortality by oral cancer in Rio de Janeiro between 2002 and 2018, with great decline in regions with ample coverage of family health strategies and specific increase of deaths by neoplasm of the base of the tongue. Cunha et al. have also reported rising trend of deaths at this site, a difficult location for clinical exam, which can delay diagnoses and aggravate prognoses[30]. These findings corroborate the patterns observed in the present study, reinforcing the importance of health primary attention and early diagnosis.

A decreasing trend was observed in the South and Southeast regions, standing out São Paulo and Rio de Janeiro with the greatest declines, possibly related to better socioeconomic conditions that favor fast and precise diagnoses, reflecting declining mortality rates[31]. The high home coverage of the family health strategy in the South region (64.8%) allied with the quality of primary attention (score 6.3 of the Primary Care Assessment Tool of 2019), demonstrates solid structure and effective action of the teams, ensuring continuity of the care[32]. In contrast, the North region presented worst evaluations (score 5.5) with difficulty of access, poor infrastructure and adverse socioeconomic conditions, exposing the heterogeneity of primary attention in the country and urgency of specific regional policies.

The North and Northeast regions presented rising trends of mortality, most of all in Acre, Maranhão, Piauí and Tocantins, marked by geographic and social limitations, poverty, poor access to health and multiple risk factors as environmental carcinogens, bad nutrition, alcohol and illicit drugs[33]. These areas, with low wealth indexes, registered increase of deaths possibly due to high socioeconomic vulnerability and obstacles of access and self-care[34]. The concentration of these trends in 13 states reinforces the importance of public policies that consider regional specificities, strengthening primary health attention, essential as first and many times only line of defense. Family health strategy and community agents working directly with the communities promote early diagnosis, close surveillance and prevention, relevant to expand coverage and qualify the services to reduce inequalities and control oral cancer at these regions[35,36].

The study limitations are inherent to secondary data obtained from SIM which, in despite of improvements of coverage and quality in the last decades, are still exhibiting regional inconsistencies, sub-notification and incomplete registers, especially in the North and Northeast regions. The elevated proportion of neoplasms of unspecified parts of the mouth (C06) also suggest possible flaws of diagnosis or codes, which can impact the analysis per anatomic site. In addition, the stability and consistency of the time series can be influenced by changes of the processes of notification and classification of deaths. These factors call for cautious interpretation of the results, most of all due to regional disparities in access to health services and quality of the information systems.

Despite these limitations, the present study contributes to further the knowledge of oral cancer while identifying temporal patterns and inequalities of mortality by oral cancer, offering relevant information for planning actions of oral health in the National Health System. The strengthening of primary health attention, expansion of the coverage of specialized services, tobacco and alcohol fighting, in addition to promotion of territorial, social and racial equity are core strategies to face mortality by oral cancer in the country. Continuous epidemiologic surveillance allied to sensitive public policies to inequalities is essential to ensure more efficacy of the prevention and control actions.

## CONCLUSION

Stationary trend of the mortality rates by oral cancer in Brazil between 1997 and 2023 was predominant, with significant declines in the Southeast and South regions and increase in the North and Northeast regions. Mortality was prevalent among men and adults older than 60 years of age, oropharynx was the most frequent anatomic site. Trends varied according to education and color/ethnicity, rising in individuals with poor education and in White, Brown, Black and Indigenous individuals.

### CONTRIBUTIONS

All the authors contributed substantially to the study design, acquisition, analysis and interpretation of the data, writing and critical review. They approved the final version for publication.

### DECLARATION OF CONFLICT OF INTERESTS

There is no conflict of interests to declare.

## DATA AVAILABILITY STATEMENT

All content underlying the text is contained in the article.

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