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ORIGINAL RESEARCH

Demographic and Geographic Heterogeneity in Tongue Cancer Mortality in the United States, 1999–2020

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Background: Tongue cancer remains a significant public health concern due to its persistently high mortality. However, population-level evidence on long-term trends and geographic inequities, particularly urban–rural disparities, remains limited. This observational ecological study examined national temporal trends and demographic and geographic heterogeneity in tongue cancer mortality.

Methods: We analyzed mortality data from 1999–2020 obtained from the Centers for Disease Control and Prevention Wide-Ranging Online Data for Epidemiologic Research (CDC WONDER). Deaths were identified using ICD-10 codes C01–C02 as the underlying cause. Age-adjusted mortality rates (AAMRs) and estimated annual percent change (EAPC) were used to quantify trends. Analyses were stratified by sex, race or ethnicity, age group, US Census region, urbanization level, and state. Frontier analysis assessed the association between state-level mortality rates and the socio-demographic index (SDI).

Results: A total of 47,943 tongue cancer deaths were recorded, with an overall AAMR of 0.660 per 100,000 population. Mortality increased modestly from 0.617 to 0.683 per 100,000 (EAPC, 0.262%). Urban–rural disparities were pronounced: urban rates remained stable (EAPC, 0.039%), whereas rural rates increased significantly (EAPC, 1.103%), reversing from lower than urban in 1999 to higher by 2020 (0.742 vs 0.662). Men experienced approximately threefold higher mortality than women, with increases confined to men. Mortality rose among White individuals but declined among Black individuals, and deaths were concentrated in older adults. Regionally, mortality increased in the Midwest and declined in the Northeast. Frontier analysis demonstrated an inverse association between SDI and AAMR.

Conclusion: Tongue cancer mortality in the US has remained relatively stable overall but exhibits widening rural disadvantages, persistent male predominance, divergent racial trends, regional heterogeneity, and a concentration among older adults. These findings underscore the need for equity-focused, geography-based interventions, particularly in rural communities.

Keywords: tongue cancer, urban–rural disparities, age-adjusted mortality, EAPC, socio-demographic index

Introduction

Tongue cancer, one of the most common malignant tumors of the head and neck, is characterized by aggressive local invasion and frequent regional lymph node metastasis, contributing to persistently high mortality worldwide.[1] While the overall oral cancer incidence has declined in some populations, the tongue cancer incidence continues to rise, a trend documented across multiple countries.[2,3] Recent epidemiological evidence further indicates increasing incidence and mortality rates in certain Western countries.[4] A United States (US) study conducted two decades ago reported a sharp increase in tongue cancer incidence among younger individuals, suggesting possible shifts in underlying etiological factors.[5] Compared with other oral cancers—even at an early stage—it carries a relatively poor prognosis and suboptimal survival outcomes,[6] underscoring its unique and ongoing public health challenge.

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Survival rates for tongue cancer vary markedly across regions worldwide. The EUROCARE II analysis of multinational European cancer-registry data found that prognosis for head and neck cancers differs substantially by country and primary tumor site.[7] For oral cancers—including tongue cancer—survival is consistently lower in Eastern compared with Western European countries even after adjusting for anatomical subsite, a pattern that likely reflects regional gaps in timely diagnosis, access to healthcare, and availability of treatment resources.[7] These geographical imbalances implicate socioeconomic development and healthcare-system capacity as major macro-level determinants of tongue cancer mortality rates.

At the national level, the Centers for Disease Control and Prevention Wide-Ranging Online Data for Epidemiologic Research (CDC WONDER) provides publicly available, de-identified death-certificate data compiled by the National Center for Health Statistics.[8] The multiple cause of death files enable reproducible estimation of age-adjusted mortality rates (AAMRs) using the 2000 US standard population and permit stratification by demographic characteristics, state, and urbanization categories. Together, these features make CDC WONDER well suited for national surveillance of tongue cancer mortality for evaluating spatial and temporal inequities.

While several US-based studies have described national trends and demographic disparities in tongue cancer incidence or mortality, most have focused primarily on sex, race or ethnicity, and age, with limited attention to geographic inequities across levels of urbanization.[9,10] Using CDC WONDER mortality data from 1999–2020, this study quantifies urban–rural differences in tongue cancer mortality, characterizes temporal trends via AAMRs and estimated annual percent change (EAPC), and examines variation by sex, race or ethnicity, and US Census region. The overarching goal is to pinpoint populations and geographic locations where targeted prevention and care-delivery interventions may yield the greatest public-health benefit.

Materials and Methods

Study Design and Data Source

We performed a cross-sectional analysis of US mortality using the CDC WONDER platform. This publicly available, de-identified database aggregates death certificate records for all 50 states and the District of Columbia. The study period covered calendar years 1999–2020. Because the data are anonymized and publicly accessible, the study was exempt from institutional review board oversight.

Case Ascertainment and Outcome Definition

Tongue cancer mortality was identified when ICD-10 codes C01 (base of tongue) or C02 (other and unspecified parts of tongue) were recorded as the underlying cause of death. The primary outcome was the AAMR per 100,000 persons.

Covariates and Stratification

We extracted death counts and corresponding population denominators for the overall population and prespecified strata: sex; race or ethnicity; 10-year age groups; US Census region (Northeast, Midwest, South, West); urbanization (urban vs rural); and state of residence. Urban–rural status was assigned according to the 2013 National Center for Health Statistics (NCHS) Urban–Rural Classification Scheme; for this analysis counties were dichotomized as urban (population ≥50,000) or rural (<50,000). Consistent with CDC WONDER suppression rules, cells with fewer than 20 deaths were suppressed to avoid unstable rate estimates.

Statistical Analysis

Descriptive analyses were conducted to summarize mortality patterns and temporal trends. Annual death counts and population denominators were obtained directly from CDC WONDER. AAMRs per 100,000 population were calculated by direct standardization to the 2000 US standard population, and 95% confidence intervals (CIs) were estimated under a Poisson distribution. Temporal trends were quantified using the EAPC derived from a log-linear regression of ln(AAMR) on a calendar year (EAPC = 100 X [exp(β)–1]); 95% CIs for the EAPC were obtained from the regression model. Positive EAPC values indicate increasing mortality over time, whereas negative values indicate declines.

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Hypothesis-generating analyses were performed using a stochastic frontier model to explore the association between state-level AAMRs and the socio-demographic index (SDI) and to benchmark relative performance across states. The model was specified as:

yi = α + β × SDIi + vi − ui

where yi is the AAMR for states i, SDIi is the SDI for the countries, α and β are regression coefficients, vi is a two-sided random error term capturing statistical noise, and ui is a non-negative term capturing technical inefficiency.

For descriptive comparisons, state AAMRs were grouped into equal-frequency quintiles (Q1–Q5) and displayed them on choropleth maps to visualize geographic patterns. Subgroup frontier analyses were performed by sex, race or ethnicity, age group, Census region, and urbanization to assess whether relative inefficiencies varied across population subgroups. All frontier estimation, mapping, and ancillary analyses were performed in R (version 4.2.0; R Foundation for Statistical Computing).

Results

Overall Trends

From 1999 to 2020, there were 47,943 US deaths attributed to tongue cancer, corresponding to an overall AAMR of 0.660 per 100,000 (Table 1). Temporal patterns differed by region: the Midwest experienced an increase (EPAC, 1.078%), the Northeast experienced a decline (EPAC, −0.683%), and other regions showed no clear change. The most pronounced heterogeneity, however, occurred along the urban–rural axis.

Urban–Rural Disparities

Urban–rural patterns diverged markedly over the study period (Table 1). Urban AAMRs remained essentially unchanged (EAPC, 0.039%; 95% CI, −0.275 to 0.354), whereas rural AAMRs increased significantly (EAPC, 1.103%; 95% CI, 0.627–1.581). In 1999, rural mortality was lower than urban rates (0.525 vs 0.648 per 100,000), but by 2020, rural rates had surpassed urban rates (0.742 vs 0.662 per 100,000). Over 1999–2020, the stable urban trend and steady rural increase produced a reversal in relative burden and a widening urban–rural gap (Table S1). Figure 1 illustrates these trajectories, showing a stable urban curve and a steadily rising rural curve that progressively widen the disparity in later years.

Sex Differences

Men consistently experienced substantially higher tongue cancer mortality than women throughout the study period (overall AAMR 0.948 vs 0.358 per 100,000). Mortality increased significantly among men (EAPC, 0.394%; 95% CI, 0.124 to 0.665), whereas rates among women remained essentially stable (EAPC, −0.191%; 95% CI, −0.544 to 0.164; Table 1). These divergent trajectories are shown in Figure 2.

Sex-stratified urban–rural analyses reveal a clear shift toward a rural disadvantage for both sexes. In 1999, women had higher urban than rural AAMRs (0.404 vs 0.303 per 100,000), but by 2020 this relationship had reversed (0.392 vs 0.481), indicating a growing rural excess (Figure S1 and Table S2). Among men, urban mortality exceeded rural mortality in 1999 (0.980 vs 0.758 per 100,000), yet rural rates rose over time and slightly surpassed urban rates by 2020 (1.010 vs 0.999 per 100,000). The rural curve overtook the urban curve in the mid-late 2010s (for example, 2016: 1.093 rural vs 1.036 per 100,000), underscoring an emergent and widening rural burden within each sex.

Age Differences

Age-specific mortality rose steadily with age: rates were peaking at individuals aged ≥85 years. Intermediate age groups preserved this ordering throughout the study period, indicating a stable age-related hierarchy of risk (Figure 3). Across both urban and rural settings, the mortality burden was dominated by older adults—particularly those aged ≥75 years and most pronounced in the ≥85-year group. Stacked-bar charts depict a consistently “top-heavy” age distribution, whereas younger age groups (<45 years) contributed only a small and persistent share of deaths (Figure S2).

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Table 1 Age-Standardized Mortality Rates and Temporal Trends of Tongue Cancer in the United States, 1999–2020

	All Year		**1999**		**2020**		**1999-2020**
	Numbers	**AAMR per 100,000 (95% CI)**	**Numbers**	**AAMR per 100,000 (95% CI)**	**Numbers**	**AAMR per 100,000 (95% CI)**	**EAPC (95% CI)**
Overall	47943	0.660 (0.654, 0.666)	1738	0.617 (0.588, 0.647)	2853	0.683 (0.657, 0.709)	0.262 (−0.044, 0.568)
Sex							
Female	15716	0.358 (0.352, 0.364)	600	0.382 (0.350, 0.413)	911	0.393 (0.367, 0.420)	−0.191 (−0.544, 0.164)
Male	32227	0.948 (0.937, 0.958)	1138	0.936 (0.881, 0.992)	1942	0.994 (0.948, 1.039)	0.394 (0.124, 0.665)
Ethnicity							
American Indian	229	0.343 (0.296, 0.391)	-	-	-	-	-
Asian or Pacific Islander	1270	0.396 (0.373, 0.419)	27	0.332 (0.210, 0.498)	111	0.493 (0.399, 0.587)	−0.058 (−1.249, 1.148)
Black or African American	4480	0.573 (0.556, 0.590)	224	0.846 (0.734, 0.958)	196	0.423 (0.362, 0.485)	−3.003 (−3.516, −2.488)
White	41964	0.683 (0.676, 0.689)	1478	0.615 (0.583, 0.646)	2531	0.725 (0.696, 0.754)	0.674 (0.387, 0.961)
Region							
Northeast	8435	0.576 (0.564, 0.589)	369	0.650 (0.583, 0.717)	471	0.613 (0.556, 0.670)	−0.683 (−1.187, −0.176)
Midwest	10668	0.652 (0.640, 0.665)	359	0.559 (0.501, 0.617)	675	0.756 (0.697, 0.814)	1.078 (0.655, 1.504)
South	17737	0.641 (0.631, 0.650)	626	0.646 (0.595, 0.697)	1048	0.635 (0.596, 0.674)	0.227 (−0.144, 0.598)
West	11103	0.693 (0.680, 0.706)	384	0.700 (0.629, 0.770)	659	0.686 (0.632, 0.739)	−0.155 (−0.543, 0.235)
Urbanization							
Metropolitan (Urban)	40038	0.637 (0.631, 0.644)	1480	0.648 (0.615, 0.682)	2365	0.662 (0.635, 0.690)	0.039 (−0.275, 0.354)
Non-metropolitan (Rural)	7905	0.626 (0.612, 0.640)	258	0.525 (0.460, 0.590)	448	0.742 (0.673, 0.811)	1.103 (0.627, 1.581)

Abbreviations: AAMR, age-adjusted mortality rate; EAPC, estimated annual percent change.

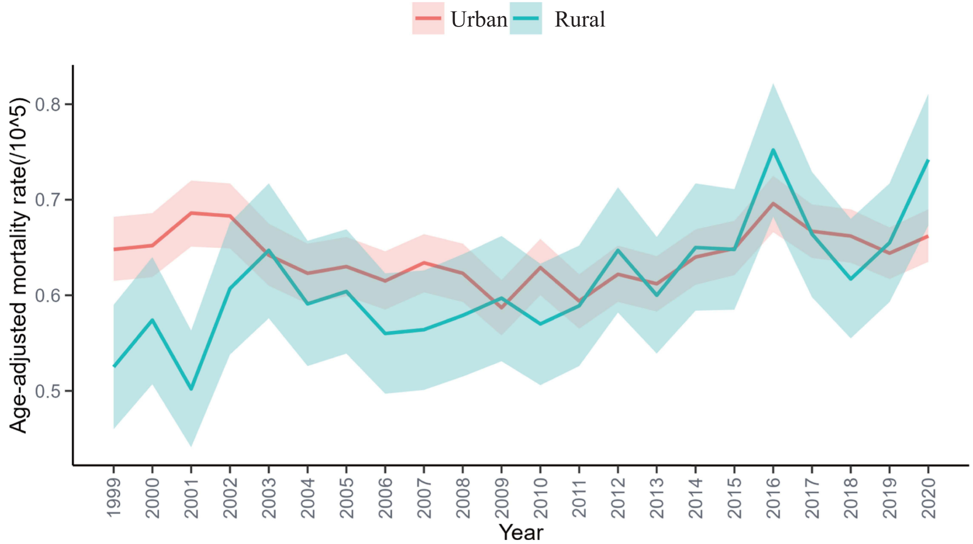

Figure 1 Temporal trends in urban–rural AAMR for tongue cancer—United States, 1999–2020. Shaded areas indicate the 95% confidence intervals.
Abbreviation: AAMR, age-adjusted mortality rate.

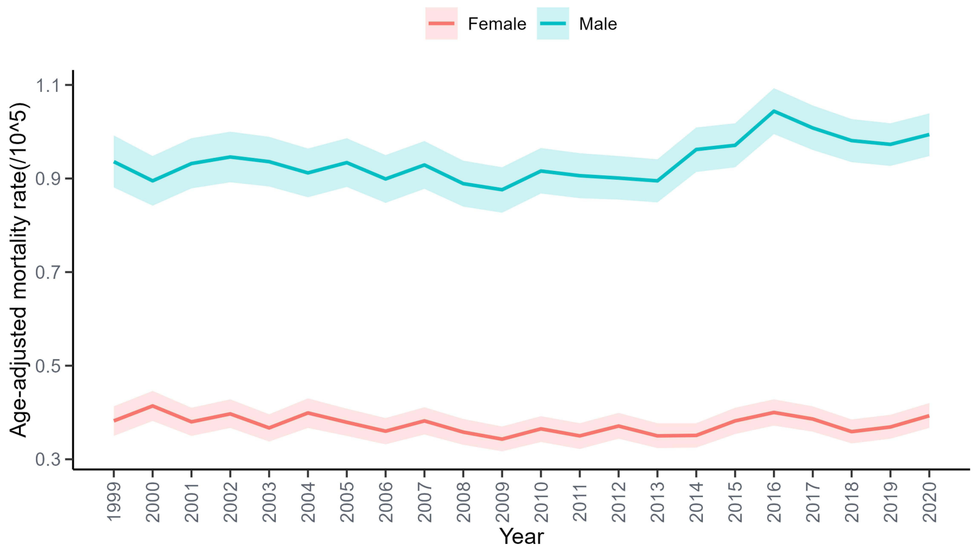

Figure 2 Sex differences in tongue cancer AAMR—United States, 1999–2020. Shaded areas indicate the 95% confidence intervals.
Abbreviation: AAMR, age-adjusted mortality rate.

Race Disparities

Overall AAMRs were highest among White individuals (0.683 per 100,000), followed by Black or African American individuals (0.573), Asian or Pacific Islander individuals (0.396), and American Indian individuals (0.343). Note that American Indian individuals' rates were not recorded in some years because of sparse data, which limits interpretation for this group (Table 1). Temporal trends diverged by race. Mortality among White individuals increased from 0.615 per 100,000 in 1999 to 0.725 in 2020 (EAPC, 0.674%, 95% CI, 0.387–0.961), whereas mortality among Black individuals declined sharply from 0.846 to 0.423 per 100,000 over the same interval (EAPC, −3.003%, 95% CI, −3.516 to −2.488), producing a mid-period crossover and a reversal of the Black–White gradient by the end of the study. Rates for Asian or Pacific Islander individuals were low overall and showed no statistically significant linear trend (1999: 0.332 to 2020: 0.493; EAPC, −0.058%; 95% CI, −1.249 to 1.148; Table 1). Stratified analyses by urbanization reveal that these racial dynamics differed by place (Figure 4). In urban areas, mortality rates among Black individuals declined, while mortality

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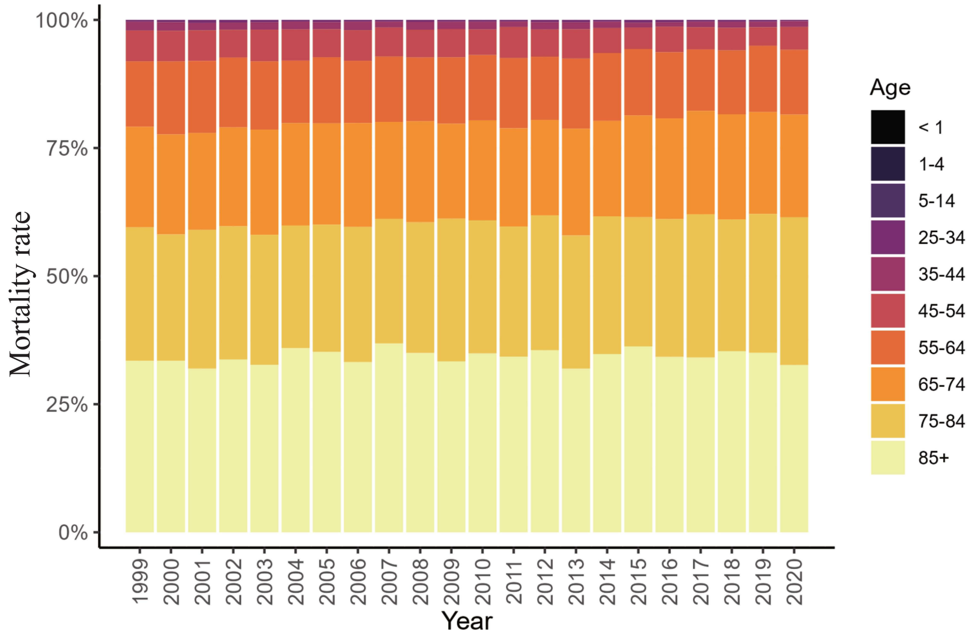

Figure 3 Age-specific trends in tongue cancer AAMR by 10-year age group—United States, 1999–2020.
Abbreviation: AAMR, age-adjusted mortality rate.

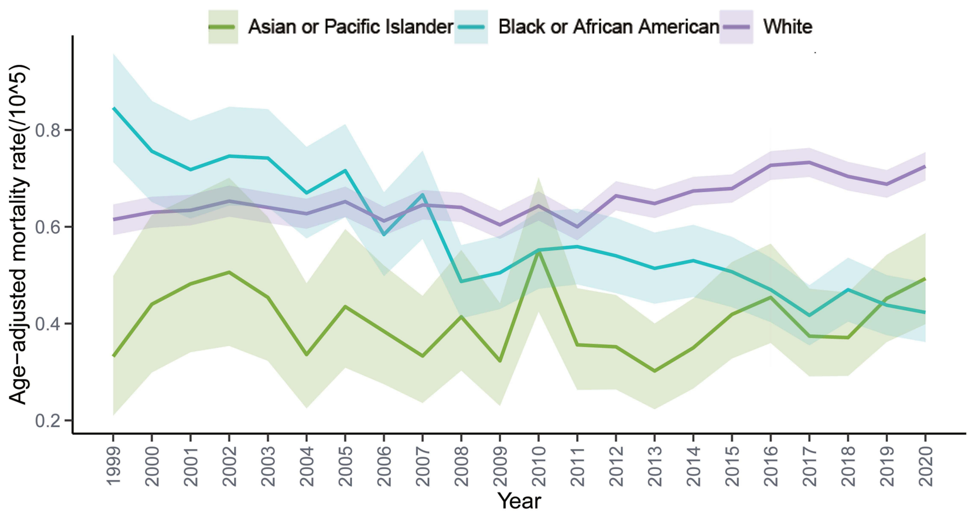

Figure 4 Racial and ethnic differences in tongue cancer AAMR—United States, 1999–2020. Shaded areas indicate the 95% confidence intervals.
Abbreviation: AAMR, age-adjusted mortality rate.

among White individuals rose modestly; rates of Asian or Pacific Islander individuals remained the lowest and largely stable In rural areas, increasing rates among White individuals and declining—but statistically unstable—rates among Black individuals contributed to the overall rise in rural mortality; in later years these changes translated into a predominantly White-driven increase in rural deaths (Figure S3).

State-Level Variation

State-level analyses revealed significant geographic heterogeneity in tongue cancer mortality. Overall, AAMRs ranged nearly twofold, from 0.420 per 100,000 in Utah to 0.835 in Washington (Figure 5). High-burden states were distributed across multiple regions, including Oregon (0.790) and California (0.708) in the West; Florida (0.754) and Tennessee (0.724) in the South; Ohio (0.729), Michigan (0.680) in the Midwest; and several Northeastern states such as New

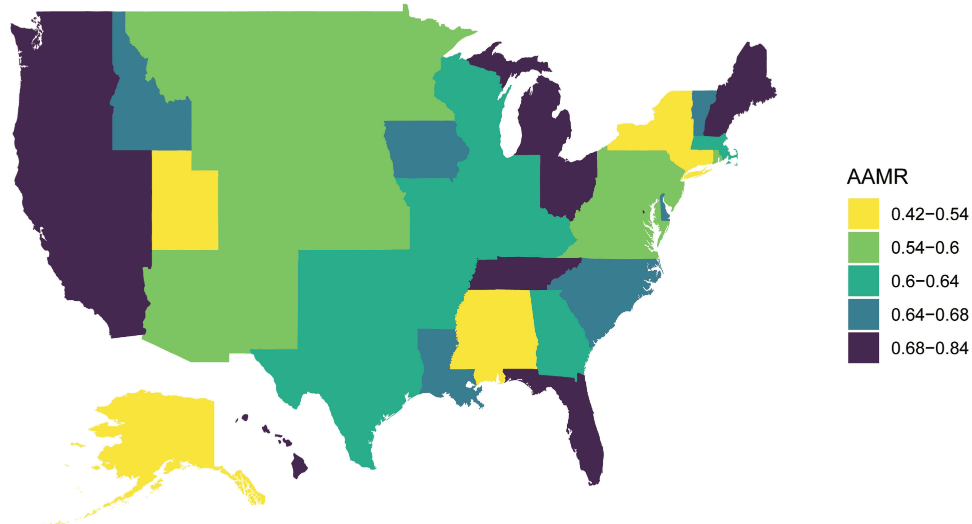

Figure 5 State-level AAMR for tongue cancer—United States, 1999–2020.
Abbreviation: AAMR, age-adjusted mortality rate.

Hampshire (0.748) and Maine (0.728). Lower-burden states clustered elsewhere, including Alaska (0.489), Connecticut (0.503), Mississippi (0.512), and Alabama (0.538), highlighting pronounced intra-regional variation (Table S3). Choropleth maps stratified by urbanization (Figure S4) further illustrated disparities. Urban AAMRs ranged from 0.42 to 0.84 per 100,000, whereas rural AAMRs exhibited a higher and wider range of 0.39 to 1.06 per 100,000, indicating greater dispersion and a higher upper bound in rural areas. Quintile classification showed that more rural states clustered in the upper two quintiles (≥0.65 per 100,000), while urban states were concentrated in the middle-to-lower quintiles (≤0.64 per 100,000). Although quintile cutpoints vary across panels and comparisons are primarily within-panel, these patterns consistently reflect a state-level rural disadvantage that mirrors national temporal trends.

Frontier analysis revealed a clear inverse relationship between socioeconomic development and tongue cancer mortality: states with higher SDI generally exhibited lower AAMRs, whereas states with lower SDI tended to have higher AAMRs (Figure 6). Notable outliers, including Oregon, New Hampshire, and Hawaii, exhibited

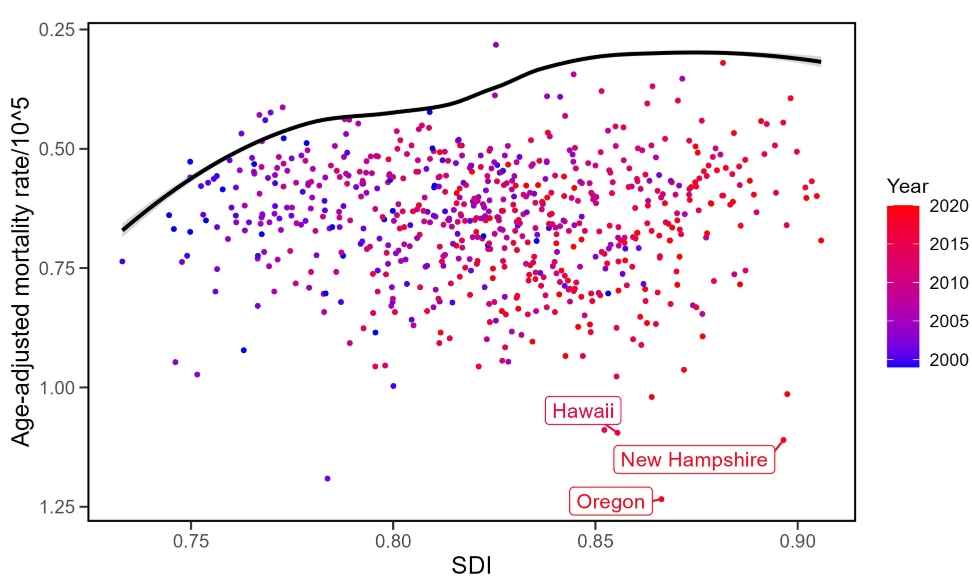

Figure 6 Frontier analysis of tongue cancer–related AAMR based on SDI—United States, 1999–2020.
Abbreviations: AAMR, age-adjusted mortality rate; SDI, socio-demographic index.

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disproportionately elevated AAMRs relative to their SDI, suggesting potential gaps in prevention, early detection, or treatment for tongue cancer.

Discussion

Our study identified pronounced sex disparities, with men experiencing approximately threefold higher tongue cancer mortality than women. Racial trends diverged: mortality increased among White individuals, declined among Black individuals. Regionally, mortality rose in the Midwest and declined in the Northeast, with significant heterogeneity across states. The most salient finding, however, is the widening rural disadvantage. AAMR in metropolitan areas remained essentially stable over the study period, whereas nonmetropolitan rates increased steadily, reversing the 1999 pattern of lower rural compared with urban mortality to higher rural mortality by 2020. This inversion occurred in both sexes: although urban rates initially exceeded rural rates, rural mortality surpassed urban rates by the end of the study period. Collectively, these results indicate that apparent national stability masks growing geography-based inequities, with rural communities bearing a disproportionate increase in tongue cancer mortality.

Globally, tongue cancer incidence and mortality have followed complex, heterogeneous trajectories. Despite declines in overall oral cancer incidence in some regions, tongue cancer incidence has risen in many countries.[11] In Finland, for example, incidence increased over time, yet five-year relative survival improved steadily from 40% in the 1950s to 58% in the 1990s, with particularly pronounced gains among patients with regional disease.[12] By contrast, data from Brazil indicate that mortality in women due to oral and base-of-tongue cancers increased significantly over the past 38 years, even as overall mortality remained relatively stable between 2000 and 2014.[9,13] Hungary experienced a nearly fourfold rise in oral cancer mortality from 1975 to 2002, a trend not fully explained by tobacco or alcohol consumption, suggesting additional systemic or environmental risk factors.[14] Collectively, these observations highlight the epidemiologic complexity of tongue cancer, with incidence and mortality shaped by geography, sex, birth cohort effects, and evolving social and behavioral exposures.

The epidemiology of tongue cancer is characterized by pronounced sex-specific differences and dynamic temporal trends. Incidence is significantly higher in men than in women, a disparity likely driven in part by greater tobacco and alcohol consumption among men.[15] For example, in Uruguay the mortality rate among men due to oral and oropharyngeal cancers is 4.34 times that of women.[15] However, in many high-income settings, incidence among younger women has risen appreciably: studies from Australia and Singapore report faster increases in women aged <45 years compared with men.[16] Sex differences in prognosis are similarly complex. A Surveillance, Epidemiology, and End Results (SEER) analysis of patients aged <40 years found superior outcomes among young women compared with men, with five-year overall and disease-specific survival rates of 75% and 67%, respectively.[17] Conversely, a Japanese study reported higher regional recurrence and poorer outcomes among young men (<40 years) treated with radiotherapy.[18] Collectively, these findings suggest that sex influences risk and temporal trends and interacts with age, lifestyle exposures, and potential biological mechanisms to shape survival outcomes in tongue cancer.

Our results indicate that older adults remain the primary contributors to tongue cancer mortality. This population often presents with multiple comorbidities and functional decline, factors that directly influence treatment selection and tolerance. A SEER-based analysis of patients aged ≥75 years with oral tongue cancer demonstrated a marked decline in the use of surgical intervention with advancing age (from 75–79 to 85–102 years).[19] In multivariable models, nonreceipt of surgery was a strong adverse prognostic factor for both overall survival (OS) and cancer-specific survival (CSS), conferring an adjusted hazard of death 2.8–3.7 times higher than for patients undergoing surgery. Importantly, surgical resection remained significantly associated with improved OS and CSS across all older age strata.[19] Similarly, another study reported statistically significant differences in OS and CSS among elderly patients with tongue cancer.[20] Collectively, these findings underscore the therapeutic complexity in the geriatric population: although age alone should not preclude surgery—given its consistent survival benefit in physiologically fit patients—there is a critical need for refined tools to optimize surgical candidacy and to identify subgroups at heightened prognostic risk, enabling truly individualized treatment decisions.

Racial and ethnic differences in tongue cancer encompass incidence, clinical presentation, and outcomes. Large SEER-based studies demonstrate that Black or African American individuals are more frequently diagnosed at later stages, with larger primary tumors and a higher likelihood of regional or distant metastasis compared with White individuals.[21] This stage disadvantage contributes to poorer survival. Moreover, in younger individuals (<45 years) with advanced (stage III–IV) oral tongue squamous cell carcinoma, Black or African American race independently predicted higher mortality (hazard ratio, 2.79). Collectively, these findings highlight the central role of race and ethnicity in the epidemiology and outcomes of tongue cancer and underscore the need to address delayed diagnosis and inequities in access to definitive therapy.

Disparities in tongue cancer incidence between urban and rural areas may be largely driven by differences in economic development. Socioeconomic status and associated social vulnerability are key non-clinical determinants that influence treatment decisions and survival outcomes for patients with tongue cancer. In the US, a large-scale retrospective study integrating the CDC's and Prevention's Social Vulnerability Index (SVI) with SEER data demonstrated the adverse impact of socioeconomic disadvantage on patient outcomes.[22] The study found that as SVI increased—indicating greater social vulnerability—both average follow-up duration and survival time declined significantly. Across vulnerability groups, mean survival decreased from 49.2 months in the lowest SVI group to 35.43 months in the highest—a 28% reduction.[22] Patients with higher social vulnerability were also likely to present with advanced-stage tumors at diagnosis. Regarding treatment, those with elevated SVI scores were less likely to undergo primary surgical resection and more likely to receive chemotherapy as first-line therapy, potentially reflecting lost surgical opportunities due to disease progression or comorbidities.[22] Similarly, a study in Bavaria, Germany, documented geographic disparities in oral cancer incidence and mortality, suggesting that regional socioeconomic differences may partly account for these patterns.[23] Collectively, these findings underscore the profound influence of socioeconomic factors on tongue cancer prognosis by shaping healthcare-seeking behaviors, timing of diagnosis, and treatment pathways. They highlight the need for public health strategies and clinical support systems that address these barriers to reduce health inequities.

To reduce the widening urban–rural gap and associated inequities in tongue cancer, we propose a multi-level strategy. First, prioritize rural communities using SVI-informed resource allocation, including mobile and tele-oncology services, transportation and coverage support, and patient navigation programs to reduce time to diagnosis and surgery. Second, integrate opportunistic oral cancer screening and referral pathways into primary care and dental settings—particularly in rural areas—and scale locally tailored tobacco and alcohol cessation programs. Third, for older adults, implement comprehensive geriatric assessments and optimize frailty and comorbidities to ensure that physiologically fit patients are not denied the survival benefits of surgery solely based on age; establish standardized time-to-treatment benchmarks and multidisciplinary tumor boards to guide clinical decision-making. Fourth, address racial and ethnic disparities by expanding timely access to definitive therapy, providing culturally adapted outreach, and offering financial counseling. Fifth, apply frontier benchmarking at state and city levels to identify high-performing regions with low AAMR relative to comparable socioeconomic conditions, disseminate their practices, and set measurable targets. Finally, strengthen surveillance by linking mortality data with geography-based social metrics, enabling small-area monitoring of disparities and rigorous evaluation of interventions. Collectively, these measures promote earlier diagnosis, equitable treatment, and accountability for outcomes in the communities with the greatest burden.

Beyond these demographic and geographic disparities, the multifactorial etiology of tongue cancer provides important context for its aggressive behavior and heterogeneous outcomes. The disease reflects a complex interplay of genetic and epigenetic alterations, dysregulated signaling pathways, and changes in the tumor immune microenvironment, together with key exposures such as tobacco, alcohol, and oncogenic human papillomavirus (HPV), particularly HPV-16.[24,25] These biological and environmental mechanisms may partially explain the observed heterogeneity in incidence and outcomes across demographic and geographic subgroups.

Our study also has several limitations. First, CDC WONDER relies on death certificates and ICD-10 coding, which are susceptible to misclassification by site, cause of death, or race or ethnicity; restricting deaths to underlying causes C01–C02 may therefore underestimate tongue cancer mortality. Second, individual-level and clinical and behavioral covariates—such as tobacco or alcohol consumption, HPV/p16 status, tumor stage and grade, treatment details, comorbidities, insurance coverage, and timeliness of care—are unavailable, limiting our ability to adjust for confounders and precluding separation of incidence versus survival effects. Third, urbanicity was assigned at the county level using the 2013 NCHS scheme and dichotomized as metropolitan versus nonmetropolitan, which may obscure important

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suburban gradients. Finally, CDC WONDER suppresses estimates for subpopulations with fewer than 20 deaths, limiting analyses in certain states and hindering finer-scale assessments of disparities.

Conclusion

Tongue cancer mortality in the United States has remained relatively stable overall, but a widening urban–rural disparity has emerged, with rural populations experiencing a disproportionate and increasing burden. Persistent male predominance and concentration of deaths among older adults further highlight vulnerable groups. These findings underscore the need for targeted, geography-informed public health strategies to improve early detection and access to effective care in rural communities.

Abbreviations

AAMR, age-adjusted mortality rate; CDC WONDER, Centers for Disease Control and Prevention Wide-ranging Online Data for Epidemiologic Research; CI, confidence interval; CSS, cancer-specific survival; EAPC, estimated annual percent change; HPV, human papillomavirus; HR, hazard ratio; ICD-10, International Classification of Diseases, Tenth Revision; NCHS, National Center for Health Statistics; OS, overall survival; SDI, Socio-demographic Index; SEER, Surveillance, Epidemiology, and End Results; SVI, Social Vulnerability Index; US, United States.

Data Sharing Statement

The datasets generated during this study are available from the corresponding author upon reasonable request.

Ethics Approval and Consent to Participate

In accordance with Article 32 of the Measures for Ethical Review of Life Science and Medical Research Involving Human Subjects of the People's Republic of China, this study was reviewed by the Ethical Review Committee of the Affiliated Huaian No.1 People's Hospital of Nanjing Medical University and qualifies for exemption from ethical review, as it exclusively uses publicly and legally accessible, de-identified data that do not pose any risk of harm to individuals and do not involve sensitive personal information or trade secrets.

Disclosure

The authors report no conflicts of interest in this work.

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