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Global, regional, and national mortality of larynx cancer from 1990 to 2021: results from the global burden of disease study



Deqian Han¹, Hoi Leong Lee^{2*}, Qi Wei Oung² and Chia Hau Lee²

Abstract

Background Larynx cancer, a major upper respiratory tract malignancy, remains a global public health challenge, driven by smoking, alcohol use, and chronic inflammation, despite medical and public health advancements.

Methods Data from the Global Burden of Disease 2021 study were used to assess larynx cancer mortality trends from 1990 to 2021 across global, regional, and national levels. Death rates, absolute mortality numbers, and Estimated Annual Percentage Change (EAPC) were calculated.

Results Globally, the number of deaths from larynx cancer increased by 36.67% between 1990 and 2021, while death rates slightly declined, with an EAPC of -0.41. Males consistently accounted for the majority of deaths, with 100,393 deaths in 2021, though female mortality showed a larger percentage increase of 60.13% compared to 33.39% in males. Significant regional disparities were evident, with the highest death rates reported in Eastern Europe and Central Latin America, where countries like Bulgaria and Cuba recorded rates exceeding 6 per 100,000 population. In contrast, Oceania reported the lowest rates, below 0.5 per 100,000. The elderly (75 + years) experienced the largest increase in mortality, rising by 85.4%, while deaths among the 15–49 age group remained relatively stable. Additionally, larynx cancer death rates were correlated with SDI.

Conclusion Despite slight declines in global death rates, the absolute burden of larynx cancer has increased due to population growth and aging. Regional disparities emphasize the need for targeted interventions and improved healthcare access. This study offers valuable insights for policy and resource planning.

Keywords Larynx cancer, Mortality trends, Public health, Global disparities

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Introduction

Larynx cancer, as a common malignancy of the upper respiratory tract, has long posed a serious challenge to global public health [1, 2]. Its major risk factors include smoking, excessive alcohol consumption, chronic inflammation, and infection with human papillomavirus (HPV) [3]. The early symptoms of larynx cancer are often subtle, leading to many patients being diagnosed at advanced stages, which significantly increases the complexity of treatment and the mortality rate [4]. Despite ongoing advancements in medical technology and public health measures, such as early screening, treatment methods, and improved patient survival rates, the global burden of larynx cancer remains heavy, with significant differences in mortality rates across regions [5].

In recent years, increasing attention has been given to the role of HPV infection in the development of larynx cancer [6]. HPV, particularly high-risk types such as HPV16, has been identified as a key pathogenic factor, especially in younger populations and female patients, with its pathogenic role becoming more evident [7, 8]. Therefore, the occurrence of larynx cancer is no longer limited to traditional risk factors, and the impact of viral infections on its pathogenesis is increasingly significant [3, 9]. Despite these advancements, early diagnosis and treatment of larynx cancer continue to face numerous challenges [10]. Most developing countries lack sufficient medical resources, resulting in inadequate early screening for larynx cancer, and patients are often diagnosed only when symptoms become apparent [11, 12]. Even in some high-income countries, the treatment of larynx cancer still requires complex approaches such as radiation therapy, surgical resection, and chemotherapy, particularly for late-stage patients, where treatment outcomes are often limited [13, 14]. As a result, the mortality rate from larynx cancer remains high in many countries, especially in regions such as Asia, Eastern Europe, and Latin America [15, 16].

This study uses data from the Global Burden of Disease (GBD) 2021 to comprehensively analyze the trends in larynx cancer mortality from 1990 to 2021 at the global, regional, and national levels [17, 18]. Through detailed analysis of data from various regions and countries, this paper aims to identify the main factors influencing changes in larynx cancer mortality and provide valuable support for the formulation of more precise public health policies worldwide. In particular, targeted interventions and resource investment in high-burden areas will be key to reducing larynx cancer mortality.

Methods

Data source

This study utilized data from the GBD 2021 database, which provides comprehensive data on disease burden,

including mortality, morbidity, and risk factors, across a wide range of regions and countries [19, 20]. The GBD study collects data from various sources such as national vital statistics, disease registries, and epidemiological studies [19, 20]. For this analysis, data on larynx cancer mortality were extracted from the GBD 2021 dataset, spanning from 1990 to 2021. Mortality data were stratified by region, country, sex, and age group, with specific age groups of 15-49 years, 50-74 years, and 75+years analyzed. This allows for a detailed analysis of trends in larynx cancer mortality across different demographics. Due to the lack of available data for the 0-14 age group, and considering that larynx cancer is rare in childhood and typically associated with different etiological factors than those in adults (such as smoking and alcohol consumption), this analysis focused on the adult population [21]. The data can be accessed through the GBD results tool at http://ghdx.healthdata.org/gbd-results-tool.

Disease definition

Larynx cancer is defined by the International Classification of Diseases (ICD) codes C32-C32.9 in the ICD-10, which refer to malignant neoplasms of the larynx, including all forms of cancer affecting this region. The corresponding ICD-9 codes are 161-161.9 and V10.21, the latter indicating a history of laryngeal cancer [22]. These codes are widely used in hospital and claims analyses to identify and track cases of larynx cancer in clinical records, making it possible to monitor trends in diagnosis, treatment, and outcomes. Larynx cancer falls under the broader category of upper respiratory tract malignancies and is primarily associated with risk factors such as smoking, excessive alcohol consumption, and HPV infection [23]. The standardized use of ICD codes ensures consistency in identifying larynx cancer cases across healthcare settings, which is essential for epidemiological studies and health policy formulation [24].

Statistical analysis

All estimates of larynx cancer deaths and cases were accompanied by 95% uncertainty intervals (UIs) based on the GBD framework. These UIs were derived from 1,000 iterations of data sampling, with the lower and upper bounds corresponding to the 25th and 975th ranked values, respectively. To assess trends in larynx cancer deaths from 1990 to 2021, the Estimated Annual Percentage Change (EAPC) was calculated. EAPC was derived by fitting a regression line to the natural logarithm of the death rates over time, using the formula: $y = \alpha + \beta x + \varepsilon$, where y represents the natural logarithm of the death rate (ln(rate)), and x is the calendar year. The EAPC itself was then computed as: EAPC = 100 × (exp(β) – 1), where β is the slope coefficient from the regression, and exp(β) is the exponentiated value of β . The 95% confidence

interval (CI) for the EAPC was derived from the regression model. An increase in death rate was indicated if both the EAPC estimate and its lower 95% CI were greater than zero. Conversely, a decrease was indicated if both the upper bound of the EAPC estimate and its 95% CI were less than zero. If neither condition was met, the rate was considered stable.

Additionally, correlation analysis was performed to examine the relationship between larynx cancer death and case rates and the Socio-Demographic Index (SDI) at global, regional, and country levels. The Pearson correlation coefficient (ρ) was used to assess the strength and direction of these relationships, with statistical significance set at p < 0.05. All analyses were conducted and visualized using R software.

Results

Global trends in larynx cancer deaths

Globally, the number of larynx cancer deaths increased significantly from 1990 to 2021, rising by 36.67% (95% UI: 25–49%), from 85,790 deaths (95% UI: 80,409 to 91,208) in 1990 to 117,252 deaths (95% UI: 109,355 to 125,952) in 2021 (Fig. 1A-C; Table 1). However, the global death rate decreased slightly over the same period, from 1.61 per 100,000 population (95% UI: 1.51 to 1.71) in 1990 to 1.49 per 100,000 population (95% UI: 1.39 to 1.6) in 2021.

The EAPC for the global death rate was -0.41 (95% CI: -0.53 to -0.29) (Fig. 1D-F; Table 1), reflecting a small but statistically significant decline over time.

Age- and sex-specific mortality trends

Males accounted for the majority of larynx cancer deaths throughout the study period. In 2021, there were 100,393 male deaths (95% UI: 93,351 to 108,830) compared to 16,859 female deaths (95% UI: 14,209 to 19,876). Despite the higher absolute number of deaths in males, the percentage increase in deaths was more pronounced in females, rising by 60.13% (95% UI: 40-99%), compared to 33.39% (95% UI: 21-46%) in males (Fig. 1A-B; Table 1). The death rate for males decreased from 2.8 per 100,000 population (95% UI: 2.63 to 3) in 1990 to 2.54 per 100,000 population (95% UI: 2.36 to 2.75) in 2021, with an EAPC of -0.47 (95% CI: -0.6 to -0.35). In contrast, the death rate for females slightly increased, rising from 0.4 per 100,000 population (95% UI: 0.31 to 0.44) in 1990 to 0.43 per 100,000 population (95% UI: 0.36 to 0.51) in 2021, with an EAPC of 0.1 (95% CI: -0.02 to 0.22) (Fig. 1C; Table 1).

Larynx cancer deaths also varied significantly across age groups. The largest increase was observed in the 75 + years age group, where deaths rose by 85.4% (95% UI: 72–100%), from 15,304 deaths (95% UI: 14,143 to 16,318) in 1990 to 28,375 deaths (95% UI: 25,586 to 30,537) in



Fig. 1 Global burden of larynx cancer deaths from 1990 to 2021 by sex and age groups. (A) Number of cases by sex (both male and female) from 1990 to 2021. (B) Percentage change in the number of cases by sex from 1990 to 2021. (C) Death rates by sex (both male and female) from 1990 to 2021. (D) Number of cases by age group (10–14, 15–19, 20–24 years) from 1990 to 2021. (E) Percentage change in the number of cases by age group from 1990 to 2021. (F) Death rates by age group (10–14, 15–19, 20–24 years) from 1990 to 2021.

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Characteristics	Cases_1990	Rates_1990	Cases_2021	Rates_2021	Cases_change %	EAPC_CI
Global	85,790(80409 to 91208)	1.61(1.51 to 1.71)	117,252(109355 to 125952)	1.49(1.39 to 1.6)	36.67(25 to 49)	-0.41 (-0.53 to -0.29)
Sex						
Male	75,262(70749 to 80447)	2.8(2.63 to 3)	100,393(93351 to 108830)	2.54(2.36 to 2.75)	33.39(21 to 46)	-0.47(-0.6 to -0.35)
Female	10,528(8183 to 11773)	0.4(0.31 to 0.44)	16,859(14209 to 19876)	0.43(0.36 to 0.51)	60.13(40 to 99)	0.1(-0.02 to 0.22)
Age						
15-49 years	9523(8683 to 10212)	0.35(0.32 to 0.38)	9775(8898 to 10869)	0.25(0.23 to 0.28)	2.64(-9 to 15)	-1.47(-1.58 to -1.36)
50–74 years	60,962(57415 to 64871)	7.95(7.49 to 8.46)	79,102(73871 to 85234)	4.82(4.5 to 5.19)	29.76(18 to 42)	-1.9(-2.02 to -1.78)
75 + years	15,304(14143 to 16318)	13.04(12.05 to 13.91)	28,375(25586 to 30537)	9.83(8.87 to 10.58)	85.4(72 to 100)	-0.93(-0.98 to -0.89)
SDI regions						
High SDI	17,522(16916 to 18077)	1.99(1.92 to 2.06)	15,698(14580 to 16475)	1.43(1.33 to 1.51)	-10.41(-15 to -6)	-1.22(-1.33 to -1.1)
High-middle SDI	27,382(26032 to 28742)	2.57(2.45 to 2.7)	25,890(23623 to 28384)	1.99(1.81 to 2.18)	-5.45(-15 to 4)	-1.14(-1.27 to -1.02)
Middle SDI	19,864(18170 to 21395)	1.15(1.05 to 1.24)	35,944(32307 to 39867)	1.47(1.32 to 1.63)	80.95(59 to 104)	0.69(0.59 to 0.79)
Low-middle SDI	15,754(13442 to 18423)	1.36(1.16 to 1.59)	30,466(27265 to 34217)	1.59(1.42 to 1.78)	93.39(61 to 131)	0.49(0.38 to 0.61)
Low SDI	5133(4033 to 6314)	1.02(0.8 to 1.26)	9099(7802 to 10534)	0.81(0.7 to 0.94)	77.28(48 to 116)	-0.88(-1.03 to -0.74)
Location						
Andean Latin America	237(207 to 272)	0.62(0.54 to 0.72)	367(286 to 458)	0.56(0.43 to 0.69)	55.05(17 to 101)	-0.39(-0.62 to -0.16)
Australasia	277(255 to 305)	1.37(1.26 to 1.51)	266(233 to 297)	0.86(0.75 to 0.96)	-4.01 (-15 to 10)	-1.59(-1.69 to -1.49)
Caribbean	748(690 to 814)	2.12(1.95 to 2.31)	1457(1264 to 1700)	3.07(2.66 to 3.58)	94.8(66 to 131)	1.37(1.28 to 1.47)
Central Asia	1378(1321 to 1442)	1.99(1.91 to 2.08)	999(891 to 1118)	1.04(0.93 to 1.17)	-27.47(-36 to -18)	-2.22(-2.36 to -2.08)
Central Europe	5604(5326 to 5920)	4.48(4.26 to 4.73)	5322(4877 to 5764)	4.62(4.23 to 5)	-5.03(-14 to 5)	0.01(-0.08 to 0.09)
Central Latin America	1645(1587 to 1699)	1 (0.97 to 1.03)	2310(2030 to 2634)	0.91(0.8 to 1.04)	40.45(24 to 59)	-0.69(-0.8 to -0.58)
Central Sub-Saharan Africa	370(264 to 493)	0.67(0.48 to 0.9)	758(559 to 982)	0.55(0.41 to 0.72)	104.87(47 to 187)	-0.7(-0.93 to -0.46)
East Asia	13,217(10939 to 15503)	1.09(0.9 to 1.27)	20,328(16104 to 25532)	1.38(1.09 to 1.73)	53.8(15 to 101)	0.78(0.63 to 0.93)
Eastern Europe	9604(9281 to 9919)	4.24(4.1 to 4.38)	6043(5361 to 6778)	2.92(2.59 to 3.28)	-37.08(-44 to -29)	-1.92(-2.15 to -1.69)
Eastern Sub-Saharan Africa	1318(1029 to 1608)	0.69(0.54 to 0.84)	2200(1725 to 2831)	0.52(0.4 to 0.66)	66.99(36 to 114)	-1.16(-1.32 to -1)
High-income Asia Pacific	1665(1460 to 1837)	0.96(0.84 to 1.06)	1634(1403 to 1815)	0.88(0.76 to 0.98)	-1.85(-16 to 15)	-0.75(-0.91 to -0.59)
High-income North America	4685(4503 to 4812)	1.66(1.6 to 1.71)	5057(4755 to 5287)	1.37(1.28 to 1.43)	7.94(4 to 12)	-0.87(-0.97 to -0.77)
North Africa and Middle East	3935(3271 to 4564)	1.16(0.96 to 1.35)	6992(6119 to 7962)	1.12(0.98 to 1.28)	77.68(45 to 114)	-0.18(-0.3 to -0.07)
Oceania	15(11 to 20)	0.23(0.17 to 0.31)	34(26 to 45)	0.24(0.19 to 0.32)	121.53(70 to 200)	0.06(0 to 0.13)
South Asia	19,009(16065 to 22229)	1.74(1.47 to 2.03)	37,433(32670 to 42841)	2.03(1.77 to 2.32)	96.93(57 to 142)	0.37(0.21 to 0.53)
Southeast Asia	3262(2831 to 3682)	0.7(0.61 to 0.79)	7055(6140 to 8307)	1.01(0.88 to 1.19)	116.24(84 to 158)	1.12(1.04 to 1.2)
Southern Latin America	1429(1331 to 1550)	2.88(2.69 to 3.13)	1176(1071 to 1282)	1.74(1.58 to 1.89)	-17.7(-27 to -7)	-1.62(-1.72 to -1.52)
Southern Sub-Saharan Africa	538(451 to 697)	1.03(0.86 to 1.33)	1022(899 to 1165)	1.27(1.12 to 1.45)	90.04(55 to 128)	0.48(0.23 to 0.74)
Tropical Latin America	2599(2492 to 2705)	1.7(1.63 to 1.77)	5593(5230 to 5917)	2.46(2.3 to 2.6)	115.18(103 to 128)	1.27(1.18 to 1.36)
Western Europe	13,231(12685 to 13722)	3.44(3.3 to 3.57)	9085(8334 to 9651)	2.08(1.91 to 2.21)	-31.34(-36 to -27)	-1.67(-1.82 to -1.51)
Western Sub-Saharan Africa	1024(814 to 1269)	0.53(0.42 to 0.66)	2119(1707 to 2568)	0.43(0.35 to 0.52)	107.04(59 to 179)	-0.6(-0.64 to -0.56)
Data in parentheses are 95% uncerta	inty intervals for cases and rates,	and 95% confidence intervals	for EAPC. Rate is expressed as per 100),000 population		

2021. Deaths in the 50–74 years group also increased, rising by 29.76% (95% UI: 18–42%) (Fig. 1D-E; Table 1). In contrast, deaths in the 15–49 years age group remained relatively stable, with an increase of only 2.64% (95% UI: -9-15%), from 9,523 deaths (95% UI: 8,683 to 10,212) in 1990 to 9,775 deaths (95% UI: 8,898 to 10,869) in 2021 (Fig. 1E; Table 1). The death rate in this group decreased from 0.35 per 100,000 population (95% UI: 0.32 to 0.38) in 1990 to 0.25 per 100,000 population (95% UI: 0.23 to 0.28) in 2021, remaining the lowest across all age groups (Fig. 1F; Table 1).

Regional variation in larynx cancer mortality rates

Larynx cancer mortality rates varied significantly across regions and SDI levels from 1990 to 2021 (Fig. 2A-B;

Table 1). In high SDI regions, such as Western Europe and High-income Asia Pacific, the death rates declined significantly over the study period. For instance, in high SDI regions, the death rate decreased from 1.99 per 100,000 population (95% UI: 1.92 to 2.06) in 1990 to 1.43 per 100,000 population (95% UI: 1.33 to 1.51) in 2021, with an EAPC of -1.22 (95% CI: -1.33 to -1.1) (Fig. 2A-B; Table 1). In contrast, low and low-middle SDI regions saw an increase in the number of deaths, despite slight declines in death rates. For example, in low SDI regions, the death rate decreased from 1.02 per 100,000 population (95% UI: 0.8 to 1.26) in 1990 to 0.81 per 100,000 population (95% UI: 0.7 to 0.94) in 2021, but the number of deaths rose by 77.28% (95% UI: 48–116%), reflecting population growth and limited healthcare access (Fig. 2A-B;



Fig. 2 Regional trends in larynx cancer deaths. (A) New cases of larynx cancer in different SDI regions from 1990 to 2021. (B) Death rates of larynx cancer in different SDI regions from 1990 to 2021. (C) Death rates of larynx cancer by sex in 2021, globally, in SDI regions, and in geographical regions

Table 1). Middle SDI regions, such as South Asia and Southeast Asia, experienced increases in both death rates and the number of deaths. The death rate in middle SDI regions increased from 1.15 per 100,000 population (95% UI: 1.05 to 1.24) in 1990 to 1.47 per 100,000 population (95% UI: 1.32 to 1.63) in 2021, with an EAPC of 0.69 (95% CI: 0.59 to 0.79) (Fig. 2A-B; Table 1).

At the regional level, the highest death rates in 2021 were observed in the Caribbean, Central Europe, and Eastern Europe, with rates of 3.07 per 100,000 population (95% UI: 2.66 to 3.58), 4.62 per 100,000 population (95% UI: 4.23 to 5), and 2.92 per 100,000 population (95% UI: 2.59 to 3.28), respectively. Despite a declining trend in death rates, both Central Europe and Eastern Europe showed significant reductions in deaths, with EAPCs of 0.01 (95% CI: -0.08 to 0.09) and -1.92 (95% CI: -2.15 to -1.69), respectively (Fig. 2C; Table 1). In contrast, the lowest death rates in 2021 were recorded in Eastern Sub-Saharan Africa, Oceania, and Western Sub-Saharan Africa, with rates of 0.52 per 100,000 population (95% UI: 0.4 to 0.66), 0.24 per 100,000 population (95% UI: 0.19 to 0.32), and 0.43 per 100,000 population (95% UI: 0.35 to 0.52), respectively (Fig. 2C; Table 1). These regions experienced either stable or modest declines in death rates over the study period, reflecting challenges in healthcare access and prevention efforts.

Country-level differences in larynx cancer deaths

Significant country-level differences in larynx cancer deaths were observed between 1990 and 2021. India, China, and the United States reported the highest number of deaths in 2021, with cases reaching 28,330 (95% UI: 24,664 to 32,829), 19,799 (95% UI: 15,580 to 25,023), and 4,620 (95% UI: 4,340 to 4,836), respectively. Other countries with notably high case numbers included Brazil, with 5,497 deaths (95% UI: 5,144 to 5,812), and Pakistan, with 5,617 deaths (95% UI: 4,106 to 7,453) (Supplementary Table S1). These countries collectively accounted for a substantial proportion of global larynx cancer deaths due to their large populations. In contrast, several smaller nations, such as Niue, Cook Islands, and American Samoa, reported fewer than 10 deaths annually, reflecting their small population sizes and lower overall burden of disease (Supplementary Table S1). Interestingly, some countries with a smaller population demonstrated rapid increases in death rates. For example, Timor-Leste and Togo saw dramatic increases in deaths by 183.7% (95% UI: 95.71-320.65%) and 289.8% (95% UI: 156.41–473.24%), respectively, highlighting the rising burden of larynx cancer in low-resource settings (Fig. 3A and Supplementary Table S1). This underscores the importance of targeted prevention and control strategies in these regions.

Despite the high absolute number of deaths, trends in death rates varied across countries. For example, countries such as India, China, and Vietnam experienced a significant increase in deaths, with India showing a 100.9% rise (95% UI: 57.89–149.21%) and an EAPC of 0.50 (Fig. 3A-C and Supplementary Table S1). Similarly, Vietnam reported a 163.4% increase in deaths (95% UI: 81.17–279.16%), with an EAPC of 2.00. In contrast, countries like Kazakhstan, Belgium, and Russia experienced notable reductions in larynx cancer deaths, with EAPCs of -3.37, -2.45, and – 2.02, respectively (Fig. 3A-C and Supplementary Table S1). The steepest decline was observed in Kazakhstan, where deaths dropped by 48.1% (95% UI: -55.73% to -38.90%) from 1990 to 2021 (Fig. 3A and Supplementary Table S1).

Countries with the highest death rates in 2021 were predominantly located in Eastern Europe and Central Latin America. Bulgaria (6.20 per 100,000 population), Cuba (8.17 per 100,000 population), Monaco (7.90 per 100,000 population), Montenegro (7.42 per 100,000 population), and Romania (5.54 per 100,000 population) recorded the highest rates (Fig. 3B and Supplementary Table S1). These elevated rates reflect the persistence of major risk factors, such as tobacco and alcohol consumption, in these regions. In contrast, countries in Oceania, such as Fiji, Vanuatu, and Kiribati, had the lowest death rates, all below 0.5 per 100,000 population (Fig. 3B and Supplementary Table S1), reflecting potentially different epidemiological patterns and risk factor exposure.

Correlation with SDI

The correlation analysis highlighted significant relationships between larynx cancer deaths and the SDI across various levels. At the global level, a moderate positive correlation was observed between EAPC and death rates in 1990 ($\rho = 0.233$, P < 0.001), indicating that regions with higher initial death rates experienced slower declines in mortality trends over time (Fig. 4A). A weaker but significant positive correlation was also found between EAPC and SDI in 2021 ($\rho = 0.151$, P = 0.031), suggesting that socio-economic development plays a role in shaping the temporal trends of larynx cancer mortality (Fig. 4B). At the regional level, a strong positive correlation ($\rho = 0.424$, P < 0.001) was identified between death rates and SDI in 2021, with regions such as Central Latin America and Eastern Europe, characterized by moderate SDI values, exhibiting the highest death rates. This pattern likely reflects the persistence of major risk factors, such as tobacco and alcohol consumption, in these socio-economic settings (Fig. 4C). At the national level, a similar trend was evident, with a moderate positive correlation $(\rho = 0.396, P < 0.001)$ between death rates and SDI in 2021. Countries with medium-to-high SDI values generally reported higher death rates compared to those with



Fig. 3 Global distribution of larynx cancer deaths in 204 countries. (A) Larynx cancer death rates by country in 2021. (B) Percentage change in larynx cancer deaths across countries from 1990 to 2021. (C) EAPC of larynx cancer deaths from 1990 to 2021



Fig. 4 Correlation between larynx cancer deaths, EAPC, and SDI. (A) Correlation between larynx cancer death rates and EAPC in 1990. (B) Correlation between the SDI and larynx cancer death rates in 2021. (C) Relationship between between larynx cancer death rates and SDI at the regional level. (D) Relationship between between larynx cancer death rates and SDI at the country level

very low or very high SDI values, reflecting differences in lifestyle risk factors, healthcare access, and disease detection rates (Fig. 4D). These findings underscore the complex interplay between socio-economic development and larynx cancer mortality patterns.

Discussion

Larynx cancer continues to be a major global public health concern, with significant disparities in mortality trends across regions and countries [25, 26]. This study provides a detailed analysis of larynx cancer mortality from 1990 to 2021 using data from the GBD 2021, revealing critical insights into the patterns and determinants of this disease. Despite advancements in medical technologies, public health interventions, and increased awareness of modifiable risk factors, such as smoking and alcohol consumption, the global burden of larynx cancer remains significant [27, 28]. While the overall global death rate has slightly declined over the last three decades, the absolute number of deaths has increased substantially due to population growth and aging, highlighting the persistent challenges in controlling this malignancy.

The uneven trends in larynx cancer mortality reflect regional and country-level disparities driven by socioeconomic, cultural, and healthcare factors. High-income countries have demonstrated substantial progress in reducing mortality, largely attributable to effective public health campaigns, improved access to healthcare, and advancements in early detection and treatment technologies [29]. For instance, countries in Western Europe and High-income Asia Pacific experienced significant reductions in death rates, supported by declining smoking prevalence and improvements in cancer care infrastructure [30]. However, despite the quality-of-life benefits of chemoradiation, studies have raised concerns about its long-term oncological efficacy, with mixed results regarding survival rates compared to traditional surgical methods like total laryngectomy [31, 32]. Regions such as Eastern Europe, Central Latin America, and parts of Asia continue to report high mortality rates. Notably, countries like Bulgaria, Cuba, and Romania had the highest death rates in 2021, reflecting the sustained impact of risk factors like smoking and alcohol consumption, compounded by limited access to advanced treatments like chemoradiation and early detection technologies [32]. Conversely, Oceania exhibited some of the lowest death rates, suggesting variations in risk factor exposure and disease patterns.

At the national level, populous countries like India and China contributed significantly to the global burden of laryngeal cancer, with over 48,000 deaths collectively in 2021. However, trends in laryngeal cancer mortality differ from those of other head and neck cancers, such as oral cavity and pharyngeal cancers [33, 34]. While the incidence of HPV-related oropharyngeal cancers has risen in high-income regions like the US and Western Europe, contributing to a decline in mortality, laryngeal cancer remains primarily driven by smoking and alcohol consumption, showing only modest improvements in death rates [35]. Moreover, early detection and advancements in treatment for oral cavity and pharyngeal cancers have resulted in more significant declines in mortality compared to laryngeal cancer [36]. In contrast, smaller nations like Timor-Leste and Togo, despite their limited populations, have seen rapid increases in mortality from both laryngeal and other head and neck cancers due to high smoking rates and limited access to healthcare. These trends highlight the need for tailored public health interventions that address both traditional risk factors, such as smoking, and emerging factors like HPV in different regions.

Emerging research highlights the role of HPV infection in larynx cancer pathogenesis, particularly in younger populations and female patients [37, 38]. High-risk HPV subtypes, such as HPV16, are increasingly recognized as key etiological factors, shifting the understanding of larynx cancer from traditional risk factors alone to a more complex interplay of viral and environmental factors [37, 39]. This shift underscores the importance of integrating HPV vaccination into public health strategies aimed at reducing the incidence and mortality of larynx cancer [39, 40]. Furthermore, advancements in genomic and molecular profiling have provided deeper insights into the biological mechanisms underlying larynx cancer, paving the way for the development of targeted therapies and precision medicine approaches [41, 42]. It is worth noting that in regions with high laryngeal cancer mortality, such as Brazil, smoking remains the primary risk factor, and the contribution of HPV to laryngeal cancer is limited. In contrast, HPV-related oropharyngeal cancers, typically occurring in younger individuals, tend to have a better prognosis [43]. This regional disparity underscores the need for targeted prevention and treatment strategies based on the dominant risk factors in different populations.

While our analysis primarily focused on mortality rates, it is important to note that other epidemiological indicators, such as incidence and prevalence, could provide a more comprehensive evaluation of the disease burden. Regions with high mortality rates may also show significant differences in incidence and prevalence, which could reflect disparities in healthcare access, early detection, and risk factor exposure. Utilizing a broader range of epidemiological metrics, including incidence, prevalence, and disability-adjusted life years (DALYs), could offer deeper insights into the global disparities in larynx cancer outcomes and better inform strategies to improve healthcare access and treatment in high-burden regions.

Age and sex remain critical determinants of larynx cancer mortality [44]. While males consistently account for the majority of deaths, the percentage increase in female mortality suggests a shift in risk factor exposure, possibly due to rising smoking prevalence among women in certain regions [27, 29]. The disproportionate increase in deaths among older adults (75+years) highlights the impact of population aging and cumulative exposure to carcinogens, whereas the stable trends in younger age groups reflect the comparatively lower burden in these populations [45, 46]. These findings call for age-specific and sex-specific public health interventions to address the unique needs of different demographic groups. Although this study is limited by the reliance on secondary data from the GBD study and may not fully capture regional variations or recent healthcare trends, with similar limitations as other GBD studies [19, 26, 47, 48], its strengths lie in its comprehensive analysis of long-term trends across multiple regions and demographics, offering valuable insights for targeted public health strategies worldwide.

Conclusions

In conclusion, larynx cancer remains a significant global health challenge with marked disparities across regions and countries. Although global death rates have shown a slight decline, the absolute number of deaths continues to increase, particularly in regions like Eastern Europe and Central Latin America, due to persistent risk factors such as smoking and alcohol consumption. Addressing these disparities requires targeted public health interventions, improved healthcare access, and strengthened prevention and control strategies to reduce the burden of larynx cancer worldwide.

Abbreviations

DALYs	Disability-adjusted life years
GBD	Global burden of disease
UI	Uncertainty interval
EAPC	Estimated annual percentage change
CI	Confidence interval
SDI	Socio-demographic index
ICD	International classification of diseases

Supplementary Information

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Supplementary Material 1

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Author contributions

D.H. was responsible for conceptualization, methodology, and data analysis. H.L.L. contributed to data acquisition and curation. Q.W.O. and C.H.L. participated in project administration and visualization. D.H. provided statistical analysis support. H.L.L. supervised the entire project and reviewed the manuscript. All authors have read and approved the final manuscript.

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Data availability

The data are available from the Global Burden of Disease Results Tool of the Global Health Data Exchange (http://ghdx.healthdata.org/).

Declarations

Ethics approval and consent to participate

Since the study used aggregated and publicly available data, the institutional review board determined that ethics approval and informed consent were not required. The research did not include any human subjects or personal identifying information.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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