Original Research

The global, regional, and national burden of laryngeal cancer and the attributable risk factors in all countries and territories during 2007–2017

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TABLE OF CONTENTS

1. Abstract

Background: Data for the global burden of laryngeal cancer (LC) are limited. **Methods**: We reported the incidence of, disability-adjusted life years (DALYs), and deaths due to LC by age, sex and by social-demographic index (SDI) in all countries and territories during 2007 to 2017, based on data from the Global Burden of Disease (GBD) 2017 study. We also assessed the risk factors for LC-associated DALYs and deaths through a comparative risk assessment framework. **Results**: Globally, from 2007 to 2017, the age-standardized incidence rate increased by 0.95%, the age-standardized DALY rate decreased by 8.75%, and the age-standardized death rate decreased by 7.66%. The age-standardized incidence, DALY, and death rates in 2017 were all the highest in the low SDI quintile. The middle SDI quintile witnessed the highest percentage changes in age-standardized incidence, DALY, and death rates during 2007–2017. At the GBD regional level, the highest age-standardized incidence, DALY, and death rates in 2017 occurred in the Caribbean, followed by South Asia. East Asia showed the largest increases in age-

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standardized incidence, DALY, and death rates from 2007 to 2017. At the national level, China and Jamaica reported the largest percentage increases in the age-standardized incidence, DALY, and death rates over the study period. **Conclusion**: The global age-standardized incidence of LC remain stable. However, the age-standardized DALY and death rates decreased significantly over the study period. **Impact**: Our findings will be beneficial for developing policies to reduce the disease burden of LC in particular regions or countries.

2. Introduction

Laryngeal cancer (LC) is one of the most common malignant tumors in the head and neck, and its incidence rate has increased significantly in recent years [1]. About 95,000 deaths were attributable to LC worldwide in 2018, the age-standardized incidence and mortality rates were 2.0 and 1.0 per 100,000, respectively globally [2].

Although some reports have described the epidemiology of LC globally [1, 2], however, no study has investigated the associations between LC burden estimates and development status in different regions. Besides, the effects of various modifiable risk factors on the global burden of the LC DALYs and death have not been investigated.

The GBD (Global Burden of Disease, Injuries, and Risk Factors Study) 2017 Study is the most comprehensive effort to date to measure the burden of disease worldwide [3]. Here, we used data from the GBD 2017 to report the disease burden due to LC in all countries and territories from 2007 to 2017, by region, age, sex, and socio-demographic index (SDI) in terms of incidence, disability-adjusted life-years (DALYs), and death. We also assessed the risk factors for LC-associated DALYs and deaths through the comparative risk assessment framework.

3. Materials and methods

3.1 Overview

This study is part of GBD 2017, which, to the best of our knowledge, is the most comprehensive and systematic effort to estimate the burden of diseases, injuries, and risk factors at global, regional, and national levels to date. GBD 2017 estimated 359 diseases and injuries; 282 causes of death; and 84 behavioral, environmental, occupational, and metabolic risk factors. The analytical framework for the GBD have been published elsewhere [3]. The GBD study follows the Guidelines for Accurate and Transparent Health Estimates Reporting.

GBD 2017 includes all countries and territories that are grouped into 21 regions on the basis of epidemiological similarities and geographical proximity. 21 regions are further grouped into 7 GBD super-regions (Central Europe, Eastern Europe, and Central Asia; High-income; Latin America and the Caribbean; North Africa and the Middle East; South Asia; Southeast Asia, East Asia, and Oceania; and Sub-Saharan Africa). The additional more detailed GBD location hierarchy table is available elsewhere [3].

3.2 Data sources

The data used in this study were derived from GBD 2017 (http://ghdx.healthdata.org/), which uses a uniform and comparable methodology to quantify health losses due to disease, disability, and risk factors for different sexes and ages in different countries and regions.

3.3 Disease burden estimation

In GBD 2017, the incidence of each nonfatal outcome was estimated primarily using the Bayesian meta-regression method DisModMR 2.1 [3]. The incidence rate of a disease is defined as the frequency of new cases of the disease occurring in a given population. The number of disability-adjusted life years (DALYs), which includes years of life lost (YLL) due to premature death and years lived with disability (YLD), is calculated by taking into account the loss of life caused by early death and disability: DALYs = YLL + YLD, where YLL = standard life expectancy – age of death, indicating the amount of life lost. YLD = number of years of disability × weight of disability, in which the number of years of disability = the number of patients × the duration of disease. The death rate is the proportion of deaths from all causes in a population in a given period.

We report here estimates of LC incidence, DALYs, and deaths. All rates are reported per 100 000 person-years. All estimates were produced from 2007 to 2017 and are reported with 95% uncertainty intervals (UIs), which were derived from the 2.5th and 97.5th percentile of 1000 draws [3].

3.4 Risk factors

We applied a comparative risk assessment framework to calculate the proportions of deaths and DALYs attributable to behavioral, environmental, occupational, and metabolic risk factors for LC. The definitions of this framework have been published elsewhere [4]. The population attributable proportion was estimated as the proportion of health outcomes obtained when reducing the exposure of a certain risk factor to the theoretical minimum exposure level. By multiplying the total DALYs due to LC by the attributable rate for each risk-outcome group by age, sex, location, and year, the DALYs due to LC caused by various risk factors were calculated.

3.5 Socio-demographic index (SDI)

In this study, the state of socioeconomic development of the country is reflected in SDI which was created as a composite of a country's total fertility rate for women younger than 25 years, the average education level, and lag-

distributed income per capita [5]. The value of SDI ranges from 0 to 1, where 0 represents the lowest lag-distributed income per capita, the lowest average education level, and the highest total fertility rate. All countries are divided into 5 levels, namely Low SDI, Low-middle SDI, Middle SDI, High-middle SDI and High SDI according to the SDI values from low to high, excluding countries with populations of less than 1 million. The SDI values ranged from a low of 0.191 in Niger to a high of 0.918 in Denmark in 2017. Additional details on the SDI calculation are available from other articles [3].

4. Results

4.1 The number of incident cases and the age-standardized incidence rate per 100,000 population by countries and territories

Supplementary Table 1 presents the number of incident cases of LC for 2017, the age-standardized incidence rate per 100,000 for 2017, the percentage change in all-age incidence counts, and the percentage change in age-standardized incidence rate between 2007 and 2017 by countries and territories. Globally, from 2007 to 2017, the number of incident cases increased to 210,605.61 (95% uncertainty interval [UI]: 206,424.04–215,538.58), representing an increase of 32.05% (28.98%–35.25%). The age-standardized incidence rate was 2.59 (2.54–2.65) per 100,000 population in 2017, representing an increase of 0.95% (–1.39% to 3.41%) from 2007 to 2017. The patterns of age-standardized incidence rate were similar between the sexes, although men consistently presented with higher numbers and rates than women, and these are summarized in **Supplementary Tables 2**,**3**, **Supplementary Figs. 1A**,**2A**.

The geographic regions with the highest age-standardized incidence rates per 100,000 population were the Caribbean with 4.64 (4.16–5.13), Central Europe with 4.39 (4.20–4.59), and Eastern Europe with 3.67 (3.54–3.81) (**Supplementary Table 1**, Fig. 1A). East Asia (38.55% [31.15%–46.89%]), the Caribbean (11.39% [–0.91% to 24.11%]), and Southeast Asia (2.99% [–4.32% to 10.17%]) showed the largest increases. In contrast, Southern sub-Saharan Africa had the largest decrease in the age-standardized incidence rate from 2007 to 2017 (–23.61% [–27.67% to –18.05%]), followed by Southern Latin America (–15.04% [–24.17% to –5.00%]) and Andean Latin America (–11.95% [–20.87% to –1.73%]) (**Supplementary Table 1**, Fig. 1D).

In 2017, the highest age-standardized incidence rate was observed in the low SDI quintile (2.84 [2.59–3.07] per 100,000 population) (**Supplementary Table 1**, Fig. 1A). The highest percentage increase in age-standardized incidence rate over the study period was observed in the middle SDI quintile (15.03% [10.61%–19.15%]) (**Supplementary Table 1**, Fig. 1D), whereas the largest decrease was observed in the high SDI quintile (–6.83% [–9.53% to –4.09%]) (**Supplementary Table 1**, Fig. 1D).

Global maps of the age-standardized LC incidence rates in 2017 and their percentage changes from 2007 to 2017 at the country level are presented in **Supplementary Table 4** and Fig. 2. At the national level, the highest age-standardized LC incidence rate per 100,000 population in 2017 was observed in Cuba (8.58 [7.37–9.83]), followed by Seychelles (7.85 [6.88–8.92]) and Montenegro (7.10 [6.17–8.18]). In contrast, the lowest age-standardized LC incidence rates per 100,000 population in 2017 were found in Samoa (0.68 [0.54–0.79]), Peru (0.73 [0.62–0.85]), and The Gambia (0.75 [0.60–0.97]) (**Supplementary Table 4**, Fig. 2A). Similar patterns were observed between males and females (**Supplementary Tables 5**,**6**, **Supplementary Figs. 3A**,**4A**).

The percentage change in the age-standardized incidence rates from 2007 to 2017 differed substantially between countries, with China (39.93% [32.14%–48.60%]), Jamaica (31.01% [3.68%–62.42%]), and Malaysia (27.46% [3.35%–52.35%]) showing the largest increases. In contrast, Iraq (–45.65% [–53.47% to 35.92%]), Qatar (–32.90% [–47.64% to 16.26%]), and Turkmenistan (–31.98% [–39.30% to 24.06%]) showed the largest decreases during this period (**Supplementary Table 4**, Fig. 2D). The 20 countries with the highest age-standardized incidence rates in 2007 and 2017 are shown in **Supplementary Fig. 5A**. **Supplementary Table 7** and **Supplementary Fig. 6A** show the number of incident cases for 2007, the number of incident cases for 2017, the global percentage change during 2007–2017, and the 2017 incidence rate by SDI quintiles across different age groups from 15 to over 80 years for both sexes. The incidence rate increased in most quintiles from ages 15 to 74 years. The incidence rate peaked at 70–74 years for the global population and the low SDI, low-middle SDI, and high SDI quintiles. Similar patterns are presented in sexes (**Supplementary Tables 8**,**9**).

Fig. 3A compares the global and regional-level observed age-standardized incidence rates from 2007 to 2017 with the expected levels based only on the SDI values of the global regions. As expected, this comparison produced a non-linear mode with a peak at SDI of about 0.80, and then decreased as the SDI value increased. The highest observed values also corresponded to an SDI of 0.80 (Central Europe). However, large regional differences were apparent. Caribbean exhibited the largest increase in the observed age-standardized incidence rate as the SDI value increases.

4.2 The DALY counts and age-standardized DALY rate per 100,000 population by countries and territories

Supplementary Table 1 presents the number of DALYs for 2017, the age-standardized DALY rate per 100,000 for 2017, the percentage change in all-age DALY

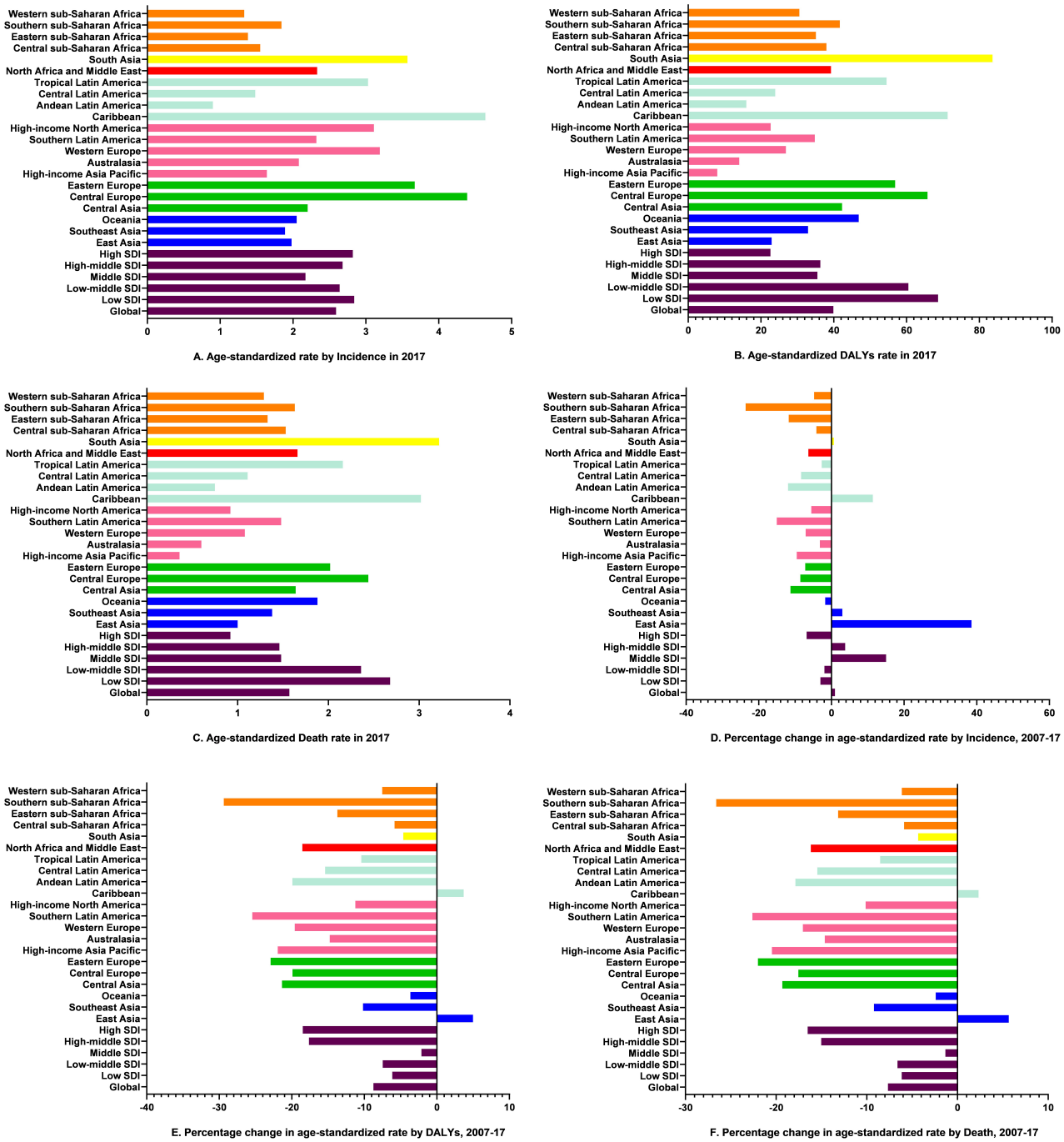

Fig. 1. Age-standardized rate by incidence (A), DALYs (B) and Death (C) in 2017; Percentage change in age-standardized rate by incidence (D), DALYs (E) and Death (F) for 2007-17 by SDI and world regions for both sexes combined.

counts, and the percentage change in age-standardized DALY rate between 2007 and 2017 by countries and territories. Globally, from 2007 to 2017, the number of DALYs increased to 3,279,461.38 (3,191,432.13–3,375,120.99), representing an increase of 17.79% (14.42%–21.37%). The age-standardized DALY rate was 39.89 (38.82–41.05) per 100,000 population in 2017, representing a decrease of 8.75% (–11.33% to –6.04%) from 2007 to 2017. The patterns of age-standardized DALY rates were similar between the sexes, although men consistently presented with higher numbers and rates than women, and these are summarized in **Supplementary Tables 2**,**3**, **Supplementary Figs. 1B**,**2B**.

In 2017, the highest age-standardized DALY rate was observed in the low SDI quintile (68.64 [62.57–74.19] per 100,000 population) (**Supplementary Table 1**, Fig. 1B). All SDI quintiles showed a decreasing trend, and the largest percentage decrease in the age-

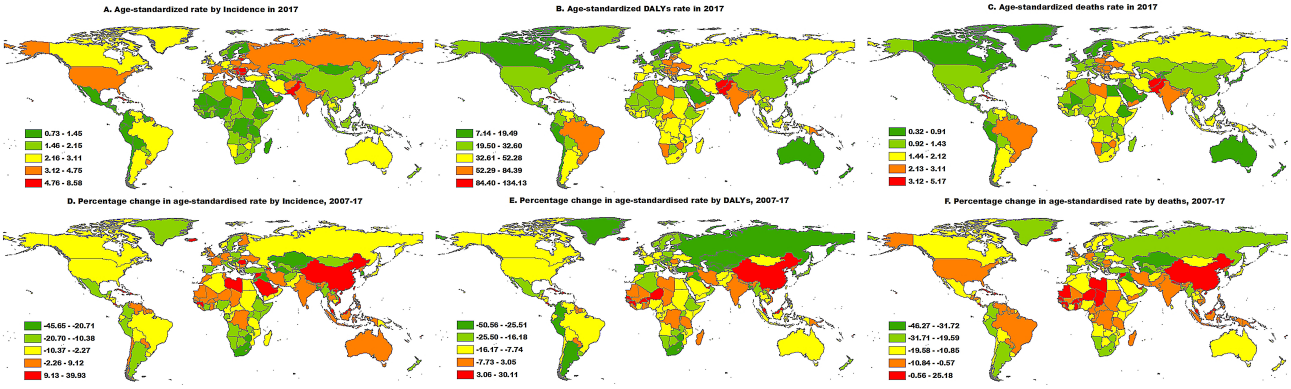

Fig. 2. Age-standardized rate by incidence (A), DALYs (B) and Death (C) in 2017; Percentage change in age-standardized rate by incidence (D), DALYs (E) and Death (F) for 2007-17 by location for both sexes combined.

standardized DALY rate over the study period was observed in the high SDI quintile (–18.48% [–20.67% to –16.10%]) (**Supplementary Table 1**, Fig. 1E).

The geographic regions with the highest age-standardized DALY rates per 100,000 population were South Asia with 83.63 (78.97–88.53), the Caribbean with 71.27 (64.26–78.58), and Central Europe with 65.76 (62.96–68.67) (**Supplementary Table 1**, Fig. 1B). Of the 21 analyzed regions, East Asia (4.97% [–0.76% to 11.12%]) showed the largest increase, followed by the Caribbean (3.69% [–7.06% to 14.32%]). In contrast, Southern sub-Saharan Africa showed the largest decrease in the age-standardized DALY rate from 2007 to 2017 (–29.38% [–33.46% to –23.78%]), followed by Southern Latin America (–25.44% [–33.51% to –16.26%]) and Eastern Europe (–22.92% [–25.53% to –20.16%) (**Supplementary Table 1**, Fig. 1E).

Global maps of the age-standardized DALY rates of LC in 2017 and the percentage change in the age-standardized DALY rates from 2007 to 2017 at the country level are presented in **Supplementary Table 4** and Fig. 2B,E. At the national level, the highest age-standardized DALY rate of LC per 100,000 population was observed in Pakistan (134.13 [106.10–164.78]), followed by Cuba (119.06 [102.44–136.00]) and Seychelles (114.52 [101.50–128.04]). The lowest age-standardized rates in 2017 were found in Japan (7.14 [6.75–7.56]), Sweden (7.73 [7.11–8.41]), and Singapore (8.43 [7.52–9.36]) (**Supplementary Table 4**, Fig. 2B). Similar patterns were observed between males and females (**Supplementary Tables 5**,**6**, **Supplementary Figs. 3B**,**4B**).

The percentage change in the age-standardized DALY rates from 2007 to 2017 differed substantially between countries, with Jamaica (30.11% [2.97%–61.40%]), Grenada (18.85% [3.14%–33.89%]), and Saint Vincent and the Grenadines (18.05% [3.67%–33.92%]) showing the largest increases. In contrast, Iraq (–50.56% [–58.03% to –41.58%]), Qatar (–43.92% [–55.76% to 30.25%]), and Jordan (–43.01% [–52.01% to –30.68%]) showed the largest decreases during this period (**Supplementary Table 4**, Fig. 2E). The 20 countries with the highest age-standardized DALY rates in 2007 and 2017 are shown in **Supplementary Fig. 5B**.

Supplementary Table 7 and **Supplementary Fig. 6B** show the number of DALYs for 2007, the number of DALYs for 2017, the global percentage change during 2007–2017, and the 2017 DALY rates by SDI quintiles across different age groups from 15 to over 80 years. The DALY rate increased in most quintiles from ages 15 to 69 years. The DALY rate peaked in the 65–69 year age group for the global population and the low, middle, high-middle, and high SDI quintiles. Similar patterns are presented in sexes (**Supplementary Tables 8**,**9**).

Fig. 3B displays the global- and regional-level observed age-standardized LC DALY rates from 2007 to 2017 and the prospective rates based on the SDI values. The age-standardized DALY rate in most regions decreases with the increase of SDI.

4.3 The death counts and age-standardized death rate per 100,000 population by countries and territories

Supplementary Table 1 also presents the number of deaths for 2017, the age-standardized death rate per 100,000 for 2017, the percentage change in all-age death counts, and the percentage change in age-standardized death rates between 2007 and 2017 by countries and territories. Globally, from 2007 to 2017, the number of deaths increased to 126,470.77 (123,375.16–129,852.63), representing an increase of 21.08% (17.81%–24.40%). The age-standardized death rate was 1.57 (1.53–1.61) per 100,000 in 2017, representing a decrease of 7.66% (–10.13% to –5.18%) from 2007 to 2017. The patterns of age-standardized death rates were similar between the sexes, although men consistently presented with higher numbers and rates than women, and these are summarized in **Supplemental Tables 2**,**3**, **Supplementary Figs. 1C**,**2C**.

In 2017, the highest age-standardized death rate was observed in the low SDI quintile (2.68 [2.44–2.89] per

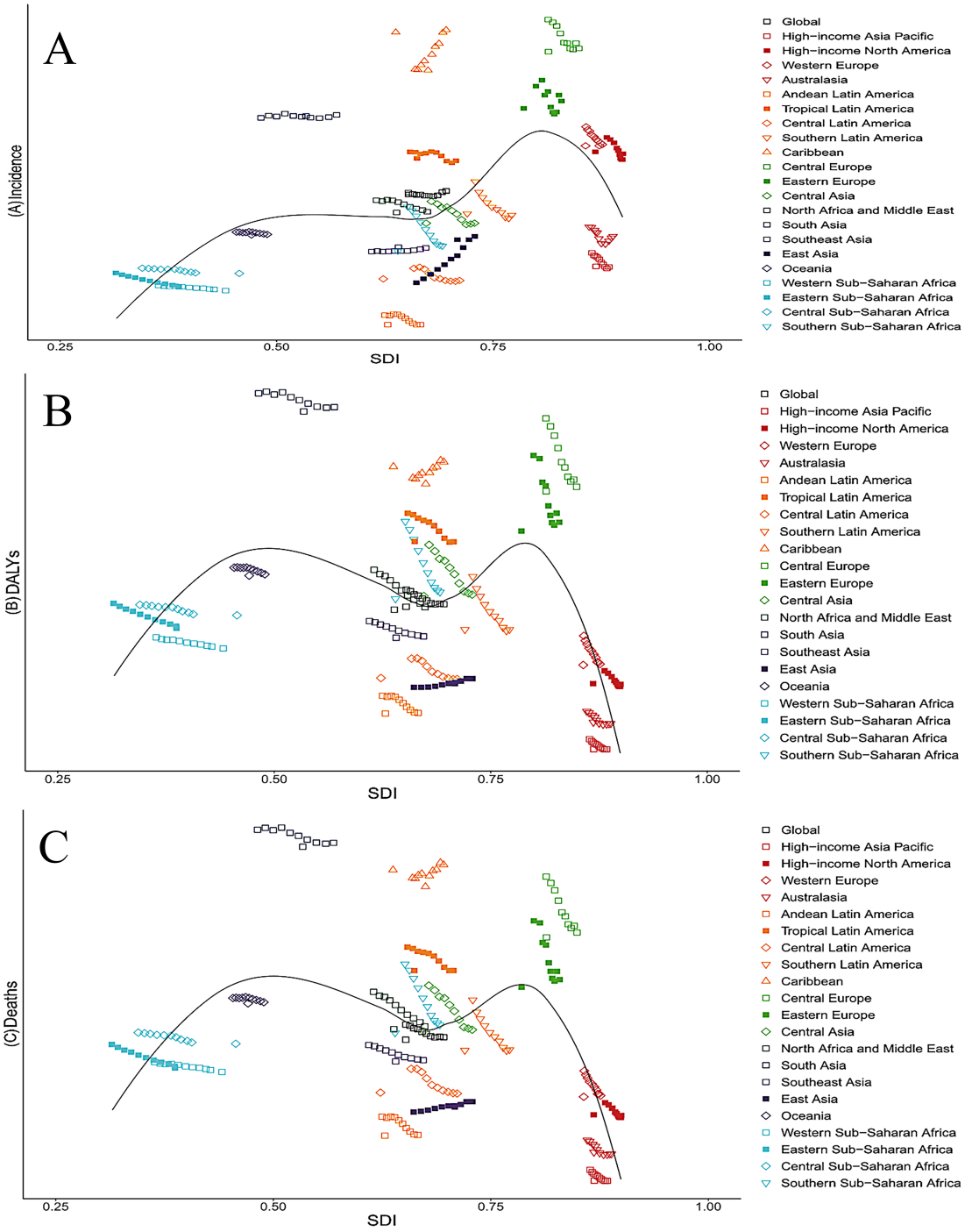

Fig. 3. The trend in age-standardized rate by Incidence (A), DALY (B) and Deaths (C) of Larynx cancer across 21 GBD regions by SDI for both sexes combined, 2007–2017.

100,000 population) (**Supplementary Table 1**, Fig. 1C). All SDI quintiles showed a decreasing trend, and the largest percentage decrease in the age-standardized death rate from 2007 to 2017 was observed in the high SDI quintile (–16.52% [–18.66% to –14.37%]) (**Supplementary Table 1**, Fig. 1F).

The geographic regions with the highest age-standardized death rates per 100,000 were South Asia with 3.22 (3.04–3.40), the Caribbean with 3.02 (2.74–3.31), and Central Europe with 2.44 (2.34–2.54) (**Supplementary Table 1**, Fig. 1C). Of the 21 regions analyzed, East Asia (5.66% [0.15%–11.57%]) and the Caribbean (2.32% [–7.82% to 12.63%]) showed the largest increases. In contrast, Southern sub-Saharan Africa had the largest decrease in age-standardized death rate from 2007 to 2017 (–26.60% [–30.32% to –21.77%]), followed by Southern Latin Amer-

ica (–22.61% [–30.53% to –13.83%]) and Eastern Europe (–22.00% [–24.49% to –19.38%]) (**Supplementary Table 1**, Fig. 2F).

Global maps of the age-standardized death rates from LC and percentage change in age-standardized death rate from 2007 to 2017 at the country level are presented in **Supplementary Table 4** and Fig. 2C,F. At the national level, the highest age-standardized death rate from LC per 100,000 population was observed in Pakistan (5.17 [4.14–6.30]), followed by Cuba (5.02 [4.35–5.70]) and Seychelles (4.62 [4.13–5.16]). The lowest age-standardized rates per 100,000 population in 2017 were found in Japan (0.32 [0.31–0.34]), Sweden (0.33 [0.31–0.36]), and Singapore (0.38 [0.34–0.43]) (**Supplementary Table 4**, Fig. 1C). Similar patterns were observed between males and females (**Supplementary Tables 5,6**, **Supplementary Figs. 3C,4C**).

The percentage change in age-standardized death rates from 2007 to 2017 differed substantially between countries, with Jamaica (25.18% [0.16%–53.22%]), Saint Vincent and the Grenadines (18.28% [5.24%–33.85%]), and Grenada (16.65% [2.09%–30.54%]) showing the largest increases. In contrast, Iraq (–46.27% [–54.24% to –36.72%]), Qatar (–44.70% [–56.27% to –31.64%]), and Turkmenistan (–38.75% [–45.20% to –31.83%]) showed the largest decreases during this period (**Supplementary Table 4**, Fig. 2F). The 20 countries with the highest age-standardized death rates in 2007 and 2017 are shown in **Supplementary Fig. 5C**.

Supplementary Table 7 and **Supplementary Fig. 6C** show the number of deaths for 2007, the number of deaths for 2017, the global percentage change during 2007–2017, and the LC-specific death rate in 2017 at the global level by SDI quintiles across different age groups from 15 to over 80 years. The death rate increased in most quintiles from ages 15 to 80 years. In 2017, the death rate peaked in the over-80-year age group in all quintiles. In the low-middle and low SDI quintiles, the LC-specific death rate increased up to 70–74 years, decreased until 75–79 years, and then increased again. Similar patterns are presented in sexes (**Supplemental Tables 8,9**).

Fig. 1C displays the global- and regional-level observed age-standardized LC death rates from 2007 to 2017 and the prospective rates based on the SDI values. The age-standardized death rate in most regions decreases with the increase of SDI.

4.4 The numbers of risk-attributable DALYs and deaths and the percentage changes in the risk-attributable age-standardized DALYs and death rates globally

The numbers of risk-attributable DALYs and deaths from LC in 2017 and the percentage changes in risk-attributable age-standardized DALY and death rates are provided for each cause in **Supplementary Table 10**. If a patient with LC can be attributed to several risk factors, then he will be counted into several risk factors. Globally, 2,374,725.62 (2,182,154.64–2,548,418.74) DALYs and 92,749.56 (85,110.51–99,160.72) deaths were attributable to GBD-reported risk factors in 2017, an increase of 13.83% (10.36%–17.20%) and 17.11% (13.73%–20.37%), respectively, from 2007 to 2017. Between 2007 and 2017, the age-standardized risk-attributable DALY rate decreased to 28.84 (26.47–30.95) per 100,000 population, representing a decrease of 12.28% (–15.00% to –9.69%). Meanwhile, the age-standardized risk-attributable death rate decreased to 1.15 (1.05–1.23) per 100,000 population, representing a decrease of 10.87% (–13.47% to –8.43%).

Tobacco use, alcohol use, dietary risks, and occupational risks were the main four level 2 risk factors in 2017. The first leading contributor to the number of DALYs was tobacco use, which contributed to 1,930,146.22 (1,696,453.23–2,133,300.29) DALYs, representing a decrease of 14.52% (–17.42% to –12.01%) in the age-standardized DALY rate from 2007 to 2017. This was followed by alcohol use, contributing to 1,013,502.41 (683,011.45–1,270,874.22) DALYs, representing a decrease of 11.51% (–16.09% to –6.55%), and then dietary risks, contributing to 198,517.48 (0.00–436,330.52) DALYs, representing a decrease of 15.95% (–20.52% to 104.41%). Similar patterns are presented in sexes (**Supplementary Tables 11,12**).

The highest number of risk-attributable deaths was associated with tobacco use, i.e., 76,700.50 (67,688.20–84,394.48), representing a decrease of 12.70% (–15.41% to –10.33%). This was followed by alcohol use, with 37,555.58 (25,127.40–47,601.79) attributable deaths, representing a decrease of 10.18% (–15.06% to –4.76%), and then occupational risks, with 7,930.67 (5,002.22–11,517.57) attributable deaths, representing a decrease of 6.85% (–11.34% to –2.67%) (**Supplementary Fig. 7**).

5. Discussion

Here, we present comprehensive global estimates of the incidence, DALYs, death counts, and age-standardized incidence and DALY rates of LC by age, sex and social-demographic index (SDI) in all countries during 2007 to 2017. Globally, there were 210,605.61 incident cases, 3,279,461.38 DALYs, and 126,470.77 deaths in 2017.

Globally, the age-standardized incidence increased slightly by 0.95% from 2007 to 2017. The stability of global age-standardized incidence estimates over time suggests that the epidemiology of LC has not changed. Recently, a global study has investigated the incidence of LC comprehensively, finding that the estimated annual percentage of age-standardized incidence rate decreased by 0.99% from 1990 to 2017 [6]. The increases in number of incident cases during 2007–2017 might be due to population growth and aging. The improvements in disease managements, ear-

lier diagnosis and better adoption of integrated therapeutic schemes, the popularity of fiber-optic laryngoscope, Computed Tomography (CT), and Magnetic Resonance Imaging(MRI) examinations contributed to the declined percentage decreases in age-standardized DALY and death rates in our study [7].

Notably, the highest age-standardized incidence, DALY, and death rates in 2017 were all observed in the low SDI quintile, and the highest percentage increase in the age-standardized incidence rate over time was observed in the middle SDI quintile, suggesting higher burdens in those regions. In less developed countries, most patients with LC are diagnosed at advanced stages due to limitations in medical facilities, resulting in poor quality of life [8]. Thus, the allocation of health resources should be prioritized to resource-limited regions.

Globally, the age-standardized DALY and death rates decreased significantly by 8.75% and 7.66%, respectively, from 2007 to 2017. As is well known, modifiable behavioral risk factors such as tobacco and alcohol use play a significant role in the development of LC [9, 10]. These risk factors exhibited decreases over the study period, consistent with significantly reduced smoking in developed countries [1]. However, smoking continues to trend upward in socioeconomically disadvantaged countries, which could increase the LC burden in those countries in the near future [1]. Therefore, it is extremely important that socioeconomically disadvantaged countries reinforce smoking cessation strategies to reduce the LC burden. Some of the approaches recommended by the WHO are increasing the price and taxation of tobacco products, limiting tobacco advertising, increasing public awareness of smoking problems, and designating smoke-free spaces [11]. A study showed that prediagnosis alcohol consumption was associated with worse survival prospects of patients with head and neck cancers. By identifying specific risk factors, policymakers can optimize their resources to improve the overall health of their countries' populations. The observed inter-country and inter-region heterogeneity suggests that prevention and intervention strategies for LC should be based on local characteristics and environments.

The estimated age-standardized incidence, DALY, and death rates also differed widely across regions. Of the 21 analyzed regions, East Asia showed the largest increases in age-standardized incidence, DALY, and death rates from 2007 to 2017. Consistent with established trends, 52.6% of LC cases and 54.9% of deaths worldwide occurred in Asia [12]. The high burden of LC in East Asia might be attributed to the high prevalence of cigarette smoking and alcohol [13]. Specific targeted prevention strategies, earlier detection, and earlier treatment, especially in populations at higher risk, should be formulated to control the endemic status of LC in East Asia [12]. At the country level, the highest percentage changes in age-standardized incidence rates were observed in China, Jamaica, and Malaysia. A previous study showed that newly diagnosed cases of LC in China account for 15.7% of the global incidence and 16.6% of the global mortality from this disease [14]. Chinese men who smoke account for more than one third of the world's total cigarette consumption [15]. All of these indicate that China should be an intervention priority for LC risk behaviors. In addition, we found that the incidence, DALY, and death rates of LC peaked in different age groups in different SDI quintiles, suggesting that effective interventions and treatment should target different age groups depending on SDI.

The main risk factors for LC are tobacco and alcohol use, which would contribute to about 90% of the overall worldwide mortality for LC [16]. Exposure to textile dust [17], polyaromatic hydrocarbons, and asbestos [18], infection with human papillomavirus [19], and red meat consumption [20] also contribute to the elevated incidence of LC. Clearly, control of exposure to risk factors and adoption of healthy lifestyles, maintaining a healthy weight should be strengthened to reduce the global burden of this disease.

To the best of our knowledge, this is the first study to estimate the risk-attributable DALYs and deaths, and the percentage changes in the risk-attributable age-standardized DALYs and deaths rates of LC, at the global, regional, and national levels in all countries and territories from 2007 to 2017. However, the GBD results were calculated based on an algorithm that used the currently available data in each country. Therefore, the UIs were greater in areas where fewer data points were available.

6. Conclusions

In conclusion, the global age-standardized incidence of LC remains stable. However, the age-standardized DALY and death rates decreased significantly over the study period. DALY, and death rates of LC increased slightly from 2007 to 2017 as a result of population growth and aging. The middle SDI quintile, East Asia, the Caribbean, China, Jamaica witnessed the highest increase in LC incidence, DALY, and death rates from 2007 to 2017. The decreased burden of LC-associated DALYs and deaths were mainly attributable to the decreases in tobacco use, alcohol use, dietary risks, and occupational risks. Controlling tobacco and alcohol consumption and minimizing occupational hazards are effective strategies to prevent and control LC.

7. Author contributions

ZSS and LYH conceived the idea for this initiative. JL and ZSS contributed to reading the literature, preparation of figures and the table, and writing the manuscript. LL was responsible for revising the manuscript. All authors read and approved the final manuscript.

8. Ethics approval and consent to participate

Not applicable.

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11. Conflict of interest

The authors declare no conflict of interest.

12. References

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