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Original Article

Asian, regional, and national burdens of respiratory tract cancers and associated risk factors from 1990 to 2019: A systematic analysis for the global burden of disease study 2019

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ABSTRACT

Background: Respiratory cancer is the leading cause of cancer-related deaths worldwide, but its statistics vary between the East and West. This study aimed to estimate the burdens of tracheal, bronchus, and lung (TBL) cancer and larynx cancer and their attributable risks from 1990 to 2019 in Asia, and at regional and national levels.

Methods: This research evaluated the incidence, mortality, years lived with disability, years of life lost, and disability-adjusted life years (DALYs) for respiratory tract cancers using the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2019 database. Age-standardized rates were calculated for TBL cancer from 1990 to 2019, adjusted for smoking and socio-demographic index (SDI). Deaths from TBL cancer and larynx cancer attributable to each risk factor were estimated for 33 Asian countries.

Results: The age-standardized incidence and death rates for TBL cancer in Asia declined from 2010 to 2019, while the incidence rate of larynx cancer increased. Smoking was the leading specific risk factor for deaths from both TBL and larynx cancers. The burden of TBL cancer in Asian countries was influenced by SDI and smoking, particularly among males in Central Asia. Deaths, DALYs, and incidences of larynx cancer in East Asia had not changed significantly over the past 30 years, but showed slight downward trends in males and both sexes combined, and an upward trend in females in recent years.

Conclusions: The past decade saw increases in numbers of incident cases and deaths from TBL cancer and larynx cancer in Asia. SDI and smoking were the main factors influencing the disease burden of TBL cancer in Asian countries. This study highlights the need for tailored cancer control programs to address the burden of respiratory tract cancers in different Asian countries.

Introduction

The global burden of tracheal, bronchus, lung, and larynx cancers is a significant public health challenge.[1] A previous Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) showed that the numbers of incident cases and deaths from tracheal, bronchus, lung (TBL) cancer and larynx cancer increased globally during the past decade.[2] Concerns have been raised over the increased age-standardized incidence and death rates due to TBL and larynx cancers globally.

Respiratory cancer is a heterogeneous disease impacted by environmental exposures and genetic and epigenetic susceptibilities to disease development and progression. Asians may have different genetic

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susceptibilities to lung cancer.[3] Asian patients with non-small cell lung cancer have a much higher prevalence of epidermal growth factor receptor mutations and a higher proportion of patients responsive to epidermal growth factor receptor tyrosine kinase inhibitors compared with Caucasian patients.[4] Asian ethnicity was identified as a favorable prognostic factor for overall survival in patients with non-small cell lung cancer, independent of smoking status.[5] Asia not only demonstrates great ethnic, cultural, and historical diversity compared with the West, but also shows great variance in economic development. Unlike the West, where most countries are developed, Asia includes developing countries such as China, as well as developed countries (Singapore, Japan, Republic of Korea). Overall, the East and West have distinct and diverse populations and geographic environmental exposures that could lead to differences in the incidence and mortality patterns of respiratory cancers. This diversity between the East and West indicates the need to examine respiratory tract cancers in Asian countries and to provide more pertinent recommendations.

Many studies have documented the epidemiology of tobacco smoking and its hazardous effects on human health. This remains a major public health problem in most Asian countries in future decades, requiring comprehensive tobacco-control programs.[6–9] A previous GBD study also reported other risk factors for TBL and larynx cancers, such as ambient particulate matter pollution and occupational exposure to asbestos.[2] These environmental exposures should also be curtailed by targeted health policies in Asia to achieve the 2030 UN Sustainable Development Goal.

The pertinent relative contribution of each risk factor to mortality from respiratory tract cancers should be clarified for each Asian country, to reduce their harmful impacts on people's lives. The present study aimed to provide Asian, regional, and national estimates of the burdens of TBL and larynx cancers and their attributable risks from 1990 to 2019, based on an analysis of the GBD 2019 data. We herein describe the burdens of respiratory tract cancers (i.e., TBL and larynx cancers) and their attributable risk factors in 30 Asian countries from 1990 to 2019 according to sex, Asian region, and socio-demographic index (SDI). The age-standardized rates for TBL cancer in Asia were adjusted for smoking and SDI, alone and combined, for three measures, death, disability-adjusted life years (DALYs), and incidence, from 1990 to 2019. We herein attempt to provide clues to resolve the problems caused by the main risk factors for respiratory tract cancers in Asia.

Methods

Overview

We extracted data specifically pertaining to Asian populations from the GBD website (https://vizhub.healthdata.org/gbd-compare/) and conducted an analysis to estimate the burdens of respiratory tract cancers (TBL and larynx cancers) and their attributable risk factors. Details of the methodology in this GBD study, including the processes used for estimating the cancer burden and risk factor quantification, have been presented in previous publications.[2,10,11] Here, we mainly present the methodology of our adjusted model of age-standardized rates for smoking, SDI, and both factors combined for three measures (death, DALY, and incidence) for TBL cancer from 1990 to 2019. The stratification of countries within Asian regions and SDI adhered to the established approach in the preceding GBD study.[2]

Estimation of mortality, incidence, and DALYs

GBD 2019 initially estimated the cancer burden by modeling cause-specific mortality.[2] We calculated the years of life lost (YLLs) associated with each cancer by multiplying the number of deaths by age using a standard life expectancy at that age.[2] DALYs were calculated by summing the years lived with disability (YLDs) and YLLs.

Risk factor estimation

GBD 2019 followed the comparative risk assessment methodology to quantify attributable burden, i.e., the reduction in current disease burden that would have been possible if past population exposure had shifted to the theoretical minimum risk exposure level.[11–13] Specific risk factors associated with each disease were selected by the World Cancer Research Fund grades for convincing or probable evidence.[2] The GBD global standard population was used to calculate age-standardized rates.[14] All rates were reported per 100,000 population in a given year, and point estimates were presented with 95% uncertainty intervals (UIs). In addition, GBD countries and territories were categorized into quintiles based on the SDI, as an index incorporating the total fertility rate in women younger than 25 years, lag-distributed income per capita, and average years of education, with a range of 0–100.[14] Asian locations were also aggregated into four main regions: East Asia, Central Asia, Southeast Asia, and South Asia.

Statistical analysis

Yearly age-standardized rates and their 95% confidence intervals for three measures (deaths, DALYs, and incidence) for TBL cancer in the included Asian countries were provided by the GBD website from 1990 to 2019. Data extraction was performed independently by three reviewers (Jianfu li, Ran Zhong, and Runchen Wang) using a Microsoft Excel spreadsheet (Microsoft, Redmond, WA, USA). The four Asian areas were analyzed according to the meta-analysis guidelines.

In our study, the age-standardized rates were adjusted for smoking, SDI, and both combined for death, DALY, and incidence for TBL cancer from 1990 to 2019. The adjusted model can be expressed as:

$$Z = \bar{Y} + \delta$$

where $\bar{Y}$ is the actual TBL cancer incidence without adjusting for smoking prevalence, Z is the actual TBL cancer incidence after adjusting for smoking or SDI or smoking and SDI combined, and δ is the residual after regression of the three measures for TBL cancer and smoking or SDI, or smoking and SDI combined.

All statistical analyses were performed using R 4.0.5 (The R Core Team, R Foundation for Statistical Computing, Vienna, Austria) running on R Studio 1.4.1106 (R Studio Team, R Studio Inc., Boston, MA, USA). Statistical significance was set at two-sided $P < 0.05$.

Results

Burden of TBL cancer

There were 1.3 (95% UI 1.2–1.5) million incident cases of TBL cancer in Asia in 2019, with 906,593 (95% UI 771,042–1,049,246) cases diagnosed in males and 398,932 (95% UI 339,662–464,457) cases in females. The total number of new cases of TBL cancer increased by 33.9% (95% UI 16.8–51.5%) in Asia between 2010 and 2019 (Table 1). The age-standardized incidence rate of TBL cancer in Asia in 2019 was 27.8 (95% UI 24.6–31.0) cases per 100,000 population in both sexes combined, with 41.2 (95% UI 35.3–47.3) cases per 100,000 in males and 16.2 (95% UI 13.7–18.8) cases per 100,000 in females.

Although the age-standardized incidence rate of TBL cancer in Asia was lower in females than in males in each year from 1990 to 2019, the rate in females increased over the study period while the rate in males decreased. The age-standardized incidence rate in females increased by 31.3% (95% UI 10.3–56.8%) from 1990 to 2019, but only increased non-significantly by 4.7% (95% UI −9.7 to 21.5%) from 2010 to 2019. In contrast, the age-standardized incidence rate in males decreased by 3.3% (95% UI −17.8 to 12.4%) between 2010 and 2019 and increased by 21.4% (95% UI 2.0 to 47.9%) since 1990.

The overall age-standardized incidence rate in Asia was 27.8 (95% UI 24.6–31.0) cases per 100,000 in 2019 (Table 1). Compared with other

Table 1
Trends in the number of incident cases and age-standardized incidence rates from 2010 to 2019 in Asia and by geographical areas, by sex, and for both sexes combined, for tracheal, bronchus, and lung cancer and larynx cancer.

Items	Incidence in 2019		Percentage change in number of incident cases, 2010–2019 (%)	Percentage change in age-standardized incidence rate, 2010–2019 (%)
	Number of cases (all ages)	Age-standardized rate (per 100,000)		
Asia				
Larynx cancer				
Both	117,342 (105,658 to 131,022)	2.4 (2.1 to 2.7)	37.3 (23.0 to 54.6)	3.5 (-7.1 to 16.4)
Males	100,220 (88,949 to 112,892)	4.2 (3.8 to 4.8)	37.5 (21.3 to 57.9)	3.9 (-8.1 to 18.7)
Females	17,122 (15,251 to 19,276)	0.7 (0.6 to 0.8)	36.1 (20.7 to 53.6)	2.4 (-9.0 to 15.5)
Tracheal, bronchus, and lung cancer				
Both	1,305,525 (1,150,171 to 1,455,350)	27.8 (24.6 to 31.0)	33.9 (16.8 to 51.5)	-0.9 (-13.2 to 11.7)
Males	906,593 (771,042 to 1,049,246)	41.2 (35.3 to 47.3)	30.4 (9.7 to 52.8)	-3.3 (-17.8 to 12.4)
Females	398,932 (339,662 to 464,457)	16.2 (13.7 to 18.8)	42.4 (22.4 to 65.8)	4.7 (-9.7 to 21.5)
East Asia				
Larynx cancer				
Both	46,604 (37,787 to 56,571)	2.2 (1.8 to 2.6)	50.1 (22.3 to 87.0)	11.6 (-8.4 to 38.3)
Males	40,028 (31,516 to 49,820)	3.9 (3.1 to 4.8)	53.3 (21.1 to 95.6)	14.8 (-8.3 to 45.8)
Females	6576 (5247 to 7982)	0.6 (0.5 to 0.7)	33.1 (6.8 to 64.9)	-2.1 (-21.3 to 20.8)
Tracheal, bronchus, and lung cancer				
Both	854,582 (721,022 to 1,002,044)	41.3 (35.0 to 48.1)	36.0 (12.1 to 62.5)	0.3 (-16.9 to 19.2)
Males	590,047 (467,100 to 722,744)	61.1 (48.9 to 73.9)	33.3 (4.5 to 69.2)	-1.0 (-21.7 to 24.0)
Females	264,535 (213,472 to 322,034)	24.6 (19.8 to 29.9)	42.6 (14.7 to 77.9)	4.2 (-16.1 to 29.6)
South Asia				
Larynx cancer				
Both	46,234 (39,850 to 53,624)	3.2 (2.7 to 3.7)	30.1 (11.1 to 51.9)	-3.2 (-17.1 to 13.0)
Males	39,176 (33,258 to 46,352)	5.4 (4.6 to 6.4)	27.9 (6.1 to 52.3)	-3.8 (-19.7 to 14.3)
Females	7059 (5881 to 8400)	0.9 (0.8 to 1.1)	43.9 (21.0 to 74.0)	6.7 (-10.1 to 28.6)
Tracheal, bronchus, and lung cancer				
Both	117,195 (100,085 to 133,943)	8.4 (7.1 to 9.5)	44.8 (23.5 to 66.4)	6.6 (-8.9 to 22.4)
Males	85,412 (69,746 to 101,658)	12.4 (10.2 to 14.7)	34.9 (10.3 to 62.3)	0.3 (-17.8 to 20.3)
Females	31,783 (25,999 to 38,175)	4.5 (3.7 to 5.4)	80.4 (46.0 to 120.7)	31.6 (-6.5 to 61.1)
Central Asia				
Larynx cancer				
Both	1793 (1607 to 2014)	2.2 (2.0 to 2.5)	9.7 (-1.3 to 22.6)	-16.1 (-24.4 to -6.8)
Males	1431 (1274 to 1630)	4.2 (3.7 to 4.7)	11.9 (0.3 to 25.5)	-14.9 (-23.2 to -5.0)
Females	362 (309 to 428)	0.8 (0.7 to 1.0)	1.7 (-13.9 to 23.1)	-19.2 (-31.0 to -2.7)
Tracheal, bronchus, and lung cancer				
Both	14,342 (12,983 to 15,870)	18.9 (17.1 to 20.8)	20.2 (8.7 to 32.9)	-6.5 (-14.9 to 2.0)
Males	11,253 (9,979 to 12,553)	34.4 (30.7 to 38.1)	18.0 (5.6 to 31.7)	-8.4 (-17.3 to 1.6)
Females	3089 (2767 to 3451)	7.4 (6.7 to 8.3)	28.9 (14.8 to 43.8)	3.2 (-7.3 to 14.5)
Southeast Asia				
Larynx cancer				
Both	10,348 (8,889 to 12,102)	1.7 (1.4 to 1.9)	43.6 (25.7 to 63.7)	6.9 (-6.1 to 21.1)
Males	9,066 (7,709 to 10,709)	3.2 (2.7 to 3.7)	46.9 (26.7 to 69.0)	9.3 (-4.8 to 25.2)
Females	1282 (1112 to 1468)	0.4 (0.3 to 0.4)	23.9 (8.2 to 42.3)	-6.7 (-17.8 to 6.6)
Tracheal, bronchus, and lung cancer				
Both	132,529 (110,981 to 153,557)	22.0 (18.4 to 25.4)	37.0 (19.8 to 55.6)	2.4 (-10.1 to 16.3)
Males	91,221 (76,900 to 106,089)	33.2 (28.2 to 38.4)	34.9 (15.1 to 56.6)	0.7 (-13.4 to 16.0)
Females	41,308 (31,631 to 51,823)	12.8 (9.8 to 15.9)	41.6 (22.0 to 63.1)	6.5 (-8.4 to 22.1)

Data are presented as values with 95% uncertainty intervals (UIs).

Asian areas, East Asia had the highest age-standardized incidence of TBL cancer throughout the study period, with 41.3 (95% UI 35.0–48.1) new cases per 100,000 in 2019. The age-standardized incidences of TBL cancer in 2019 were 22.0 (95% UI 18.4–25.4) new cases per 100,000 in Southeast Asia, 18.9 (95% UI 17.1–20.8) new cases per 100,000 in Central Asia, and 8.4 (95% UI 7.1–9.5) new cases per 100,000 in South Asia. However, Central Asia saw the largest decline in age-standardized incidence rate from 2010 to 2019 (−6.5%, 95% UI −14.9 to 2.0%), while South Asia saw the largest increase (6.6%, 95% UI −8.9 to 22.4%) (Table 1).

TBL cancer was the primary cause of cancer-related mortality in Asia in 2019, accounting for almost twice as many deaths as the next highest cancer. A total of 1.2 million deaths (95% UI 1.1–1.3) were attributed to TBL cancer, with 825,738 deaths (706,207–949,796) in males and 364,778 deaths (312,089–421,085) in females (Table 2). The age-standardized death rates due to TBL cancer in 2019 were 25.8 (22.8–28.7) per 100,000 in both sexes combined, 38.3 (33.0–43.8) per 100,000 in males, and 15.0 (12.8–17.3) per 100,000 in females. The age-standardized death rate for TBL cancer in Asia decreased by 3.4% (−14.6 to 8.7%) between 2010 and 2019 in both sexes combined, with a 5.8% (−19.2 to 9.4%) decrease in males and a 2.1% (−12.1 to 17.3%) increase in females.

TBL cancer accounted for 27.1 million (95% UI 24.0–30.4) DALYs in Asia in 2019, with 98.8% attributable to YLLs and 1.2% to YLDs. The age-standardized DALY rate for TBL cancer in Asia was almost 1.5 times higher in males than in females (Table 2). Globally, the age-standardized DALY rate for both sexes combined declined by 4.4% (−16.2 to 8.6%) from 2010 to 2019.

Although the age-standardized rates of incidence, death, and DALYs for TBL cancer decreased in Asia over the past decade, non-significant in-

Table 2
DALYs and deaths in 2019 (counts and age-standardized rates) and trends from 2010 to 2019, in Asia and by geographical areas, by sex and for both sexes combined, for tracheal, bronchus, and lung cancer and larynx cancer.

	DALYs			Deaths		
Items	Number of DALYs in 2019	Age-standardized rate (per 100,000) in 2019	Percentage change in age-standardized rate, 2010–2019 (%)	Number of deaths in 2019	Age-standardized rate (per 100,000) in 2019	Percentage change in age-standardized rate, 2010–2019 (%)
Asia						
Larynx cancer						
Both	1,999,569 (1,823,155 to 2,221,579)	39.7 (36.2 to 44.0)	-6.5 (-15.3 to 3.9)	74,164 (67,513 to 82,122)	1.5 (1.4 to 1.7)	-6.3 (-15.1 to 3.4)
Males	1,686,682 (1,505,095 to 1,905,211)	68.4 (61.1 to 77.2)	-6.5 (-16.6 to 5.2)	62,455 (56,046 to 70,338)	2.7 (2.4 to 3.1)	-6.3 (-16.3 to 4.7)
Females	312,887 (276,069 to 355,744)	12.3 (10.9 to 14.0)	-4.5 (-15.5 to 7.9)	11,709 (10,325 to 13,304)	0.5 (0.4 to 0.5)	-5.0 (-16.0 to 6.9)
Tracheal, bronchus, and lung cancer						
Both	27,120,537 (23,951,875 to 30,414,194)	553.7 (488.6 to 619.8)	-4.4 (-16.2 to 8.6)	1,190,516 (1,052,836 to 1,330,529)	25.8 (22.8 to 28.7)	-3.4 (-14.6 to 8.7)
Males	19,032,930 (16,188,395 to 21,991,610)	806.4 (688.1 to 928.3)	-6.5 (-20.6 to 9.7)	825,738 (706,207 to 949,796)	38.3 (33.0 to 43.8)	-5.8 (-19.2 to 9.4)
Females	8,087,606 (6,962,536 to 9,358,865)	321.2 (276.6 to 371.3)	1.3 (-13.7 to 17.5)	364,778 (312,089 to 421,085)	15.0 (12.8 to 17.3)	2.1 (-12.1 to 17.3)
East Asia						
Larynx cancer						
Both	513,592 (427,581 to 614,919)	23.8 (19.9 to 28.3)	-8.7 (-24.9 to 10.9)	20,852 (17,425 to 24,813)	1.0 (0.8 to 1.2)	-8.6 (-24.5 to 10.0)
Males	435,207 (351,309 to 534,073)	41.5 (33.7 to 50.7)	-6.0 (-25.1 to 15.4)	17,350 (14,023 to 21,240)	1.8 (1.5 to 2.2)	-6.4 (-24.7 to 14.4)
Females	78,385 (63,574 to 94,602)	7.3 (5.9 to 8.8)	-18.0 (-35.0 to -0.2)	3502 (2820 to 4212)	0.3 (0.3 to 0.4)	-16.8 (-33.7 to 1.2)
Tracheal, bronchus, and lung cancer						
Both	17,614,063 (14,810,292 to 20,721,521)	825.8 (696.8 to 969.5)	-5.3 (-21.4 to 13.7)	778,387 (658,108 to 907,254)	38.4 (32.7 to 44.6)	-4.0 (-19.2 to 14.1)
Males	12,285,616 (9,702,712 to 15,269,024)	1195.5 (950.0 to 1478.0)	-6.3 (-27.1 to 18.2)	536,789 (427,357 to 661,038)	57.5 (46.3 to 69.7)	-5.4 (-24.9 to 17.4)
Females	5,328,447 (4,314,330 to 6,510,671)	489.7 (396.1 to 597.2)	-1.6 (-22.5 to 22.3)	241,598 (196,028 to 289,422)	22.7 (18.5 to 27.2)	-0.4 (-20.1 to 22.5)
South Asia						
Larynx cancer						
Both	1,134,591 (978,901 to 1,320,895)	74.7 (64.4 to 86.6)	-8.2 (-21.3 to 7.0)	39,867 (34,417 to 46,259)	2.8 (2.4 to 3.2)	-7.7 (-20.4 to 7.2)
Males	958,426 (805,980 to 1,142,461)	127.3 (107.1 to 151.6)	-8.7 (-23.5 to 8.6)	33,848 (28,527 to 40,005)	4.9 (4.1 to 5.7)	-8.1 (-22.6 to 8.4)
Females	176,165 (146,987 to 211,070)	22.8 (19.0 to 27.3)	1.1 (-16.0 to 21.4)	6019 (5026 to 7213)	0.8 (0.7 to 1.0)	1.5 (-15.2 to 21.7)
Tracheal, bronchus, and lung cancer						
Both	3,089,930 (2,617,375 to 3,550,873)	208.5 (176.6 to 239.6)	5.0 (-10.6 to 20.6)	119,644 (101,195 to 137,368)	8.8 (7.4 to 10.1)	6.0 (-9.4 to 21.3)
Males	2,242,983 (1,835,005 to 2,652,810)	306.7 (251.0 to 362.0)	-1.3 (-19.9 to 18.0)	87,160 (71,240 to 102,821)	13.0 (10.7 to 15.3)	-0.2 (-18.1 to 18.4)
Females	846,947 (692,032 to 1,029,549)	112.8 (92.2 to 136.9)	29.9 (-3.8 to 60.2)	32,485 (26,638 to 39,104)	4.7 (3.9 to 5.6)	30.8 (-5.0 to 60.4)
Central Asia						
Larynx cancer						
Both	39,091 (34,910 to 44,065)	46.7 (41.8 to 52.4)	-21.9 (-29.7 to -12.8)	1339 (1200 to 1509)	1.8 (1.6 to 2.0)	-20.5 (-28.0 to -12.0)
Males	31,029 (27,567 to 35,211)	84.5 (75.2 to 95.8)	-20.9 (-28.7 to -11.4)	1080 (964 to 1224)	3.4 (3.0 to 3.8)	-19.0 (-26.8 to -9.8)
Females	8062 (6856 to 9538)	17.4 (14.8 to 20.5)	-24.6 (-35.9 to -9.1)	259 (222 to 305)	0.6 (0.5 to 0.7)	-24.2 (-34.8 to -9.8)
Tracheal, bronchus, and lung cancer						
Both	387,448 (349,153 to 429,746)	473.7 (428.6 to 523.6)	-9.0 (-17.7 to 0.7)	13,990 (12,661 to 15,452)	19.0 (17.3 to 20.9)	-7.0 (-15.1 to 1.8)
Males	305,280 (269,545 to 342,706)	845.2 (750.3 to 941.0)	-11.1 (-20.2 to -1.0)	10,955 (9,718 to 12,201)	35.0 (31.2 to 38.7)	-8.7 (-17.5 to 1.1)
Females	82,168 (73,024 to 92,405)	185.3 (165.2 to 207.5)	1.0 (-10.3 to 12.8)	3035 (2724 to 3375)	7.5 (6.8 to 8.4)	2.1 (-7.9 to 13.1)
Southeast Asia						
Larynx cancer						
Both	189,943 (162,714 to 221,319)	29.1 (25.2 to 33.8)	-3.7 (-14.8 to 8.0)	7126 (6179 to 8258)	1.2 (1.0 to 1.4)	-3.0 (-13.6 to 7.9)
Males	163,789 (139,081 to 194,005)	53.8 (45.8 to 63.5)	-1.8 (-13.9 to 11.1)	6099 (5195 to 7192)	2.3 (1.9 to 2.7)	-0.7 (-12.4 to 11.7)
Females	26,154 (22,344 to 30,157)	7.7 (6.6 to 8.8)	-13.7 (-25.5 to -1.9)	1028 (895 to 1171)	0.3 (0.3 to 0.4)	-12.3 (-23.3 to -1.5)
Tracheal, bronchus, and lung cancer						
Both	2,378,099 (1,995,969 to 2,766,343)	532.9 (445.9 to 615.8)	0.4 (-12.1 to 12.9)	134,566 (112,781 to 155,885)	23.0 (19.2 to 26.6)	1.7 (-10.4 to 13.6)
Males	1,051,621 (796,523 to 1,324,390)	795.2 (672.7 to 921.6)	-1.2 (-15.1 to 13.9)	92,416 (78,453 to 106,933)	35.0 (29.8 to 40.4)	0.0 (-13.3 to 13.6)
Females	3,429,720 (2,859,905 to 3,965,337)	308.5 (233.1 to 387.3)	4.3 (-10.9 to 20.3)	42,151 (32,050 to 52,566)	13.4 (10.2 to 16.6)	6.0 (-9.0 to 20.7)

Data are presented as values with 95% uncertainty intervals (UIs). DALYs: Disability-adjusted life-year.

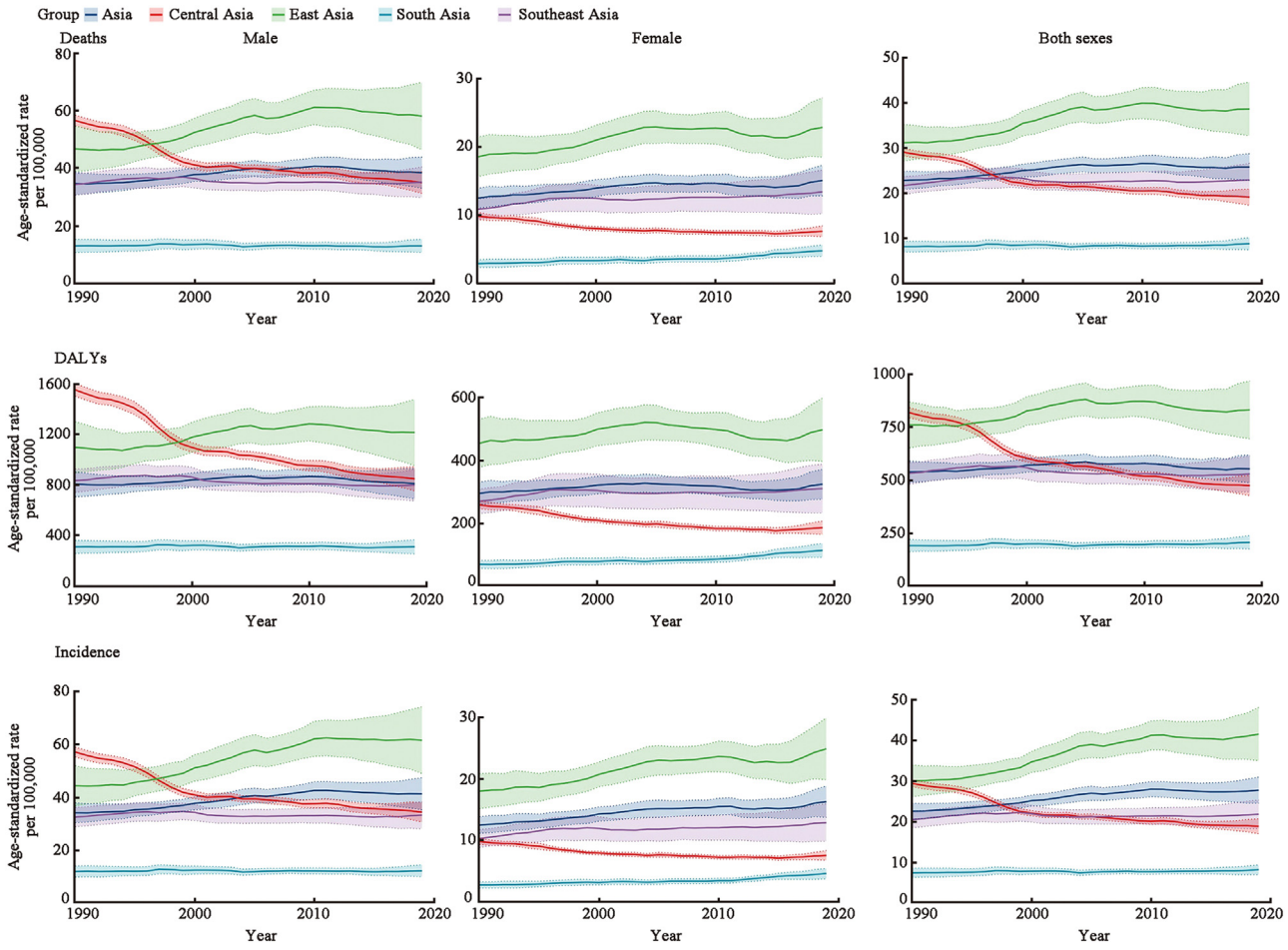

Fig. 1. Trends in age-standardized rates of TBL cancer, 1990–2019. Deaths for males, females, and both sexes combined; DALYs for males, females, and both sexes combined; and incidence for males, females, and both sexes combined. DALYs: Disability-adjusted life years; TBL: Tracheal, bronchus, and lung.

creases in all three measures were observed in South and Southeast Asia (Supplementary Table 1). Non-significant increases in age-standardized rates of incidence were observed in East Asia, with a more substantial increase among females than males, consistent with the global trend. More detailed national-level estimates are summarized in Supplementary Tables 1 and 2.

The age-standardized rates of TBL cancer incidences, deaths, and DALYs in Asia remained relatively stable from 1990 to 2019, with no significant fluctuations. However, the incidence and death rates have been consistently higher in males than in females in Asia since 1990, but both the incidence and death rates have increased in females in recent years. The incidence and death rates varied among regions in Asia, with Central Asia showing continuous declines in both rates for TBL cancer in males and females (Fig. 1). In contrast, East Asia showed slow upward trends in incidences and deaths, particularly among females.

After adjusting for smoking and SDI (Fig. 2), the incidences and deaths of TBL cancer in Central Asia decreased from 1990 to 2000, followed by upward trends from 2000 to 2019, especially in males. Conversely, none of the three measures (deaths, DALYs, and incidences) showed any significant changes over the past 30 years in East Asia, with slight downward trends in both males and both sexes combined and upward trends in females in recent years. After adjusting for smoking and SDI, the trends remained stable in South and Southeast Asia, with no significant fluctuations in any of the three measures. These findings, adjusted for smoking or SDI, are summarized in Supplementary Figures 1 and 2, respectively.

Burden of larynx cancer

There were an estimated 117,342 (95% UI 105,658–131,022) incident cases of larynx cancer globally in both sexes in 2019, with 100,220 (88,949–112,892) cases in males and 17,122 (15,251–19,276) cases in females (Table 1). The incidence of larynx cancer increased by 37.3% (23.0–54.6%) between 2010 and 2019 (Table 1), while the age-standardized incidence rate in Asia increased by 3.5% (−7.1 to 16.4%) over the same period.

The number of deaths attributable to larynx cancer globally in 2019 was 74,164 (95% UI 67,513–82,122) for both sexes combined, with 62,455 (56,046–70,338) deaths in males and 11,709 (10,325–13,304) deaths in females. The age-standardized death rate for larynx cancer in Asia decreased between 2010 and 2019 (−6.3% [−16.3 to 4.7%] in males and −5.0% [−16.0 to 6.9%] in females) (Table 2). A total of 2.0 (1.8–2.2) million DALYs were attributable to larynx cancer in 2019, with 96.8% attributable to YLLs and 3.2% to YLDs. The age-standardized DALY rates for larynx cancer in Asia decreased by 6.5% (−15.3 to 3.9%) from 2010 to 2019 for both sexes combined. The age-standardized DALY rate for larynx cancer was approximately 4.6 times higher in males than in females (Table 2). The age-standardized DALY rates for larynx cancer were highest in South Asia (74.7 [64.4–86.6] per 100,000) and lowest in East Asia (23.8 [19.9–28.3] per 100,000) in 2019. The age-standardized incidence of larynx cancer increased over the past decade in Asia, while the age-standardized death and DALY rates declined. More detailed estimates for larynx cancer at the regional and national levels are summarized in Supplementary Table 3.

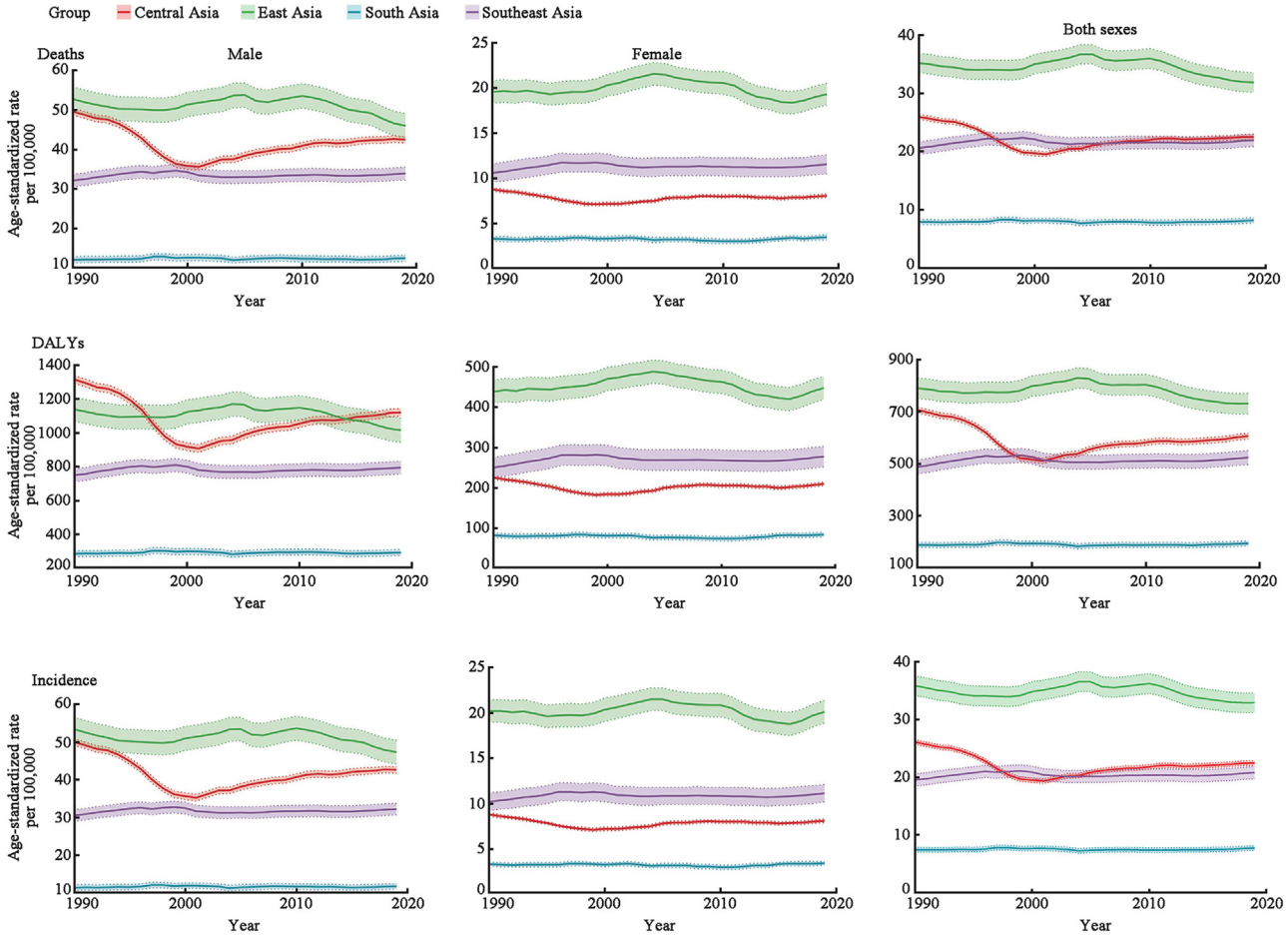

Fig. 2. Trends in age-standardized rates of TBL cancer, 1990–2019, adjusted for smoking and SDI. Deaths for males, females, and both sexes combined; DALYs for males, females, and both sexes combined; and incidence for males, females, and both sexes combined. DALYs: Disability-adjusted life years; SDI: Socio-demographic index; TBL: Tracheal, bronchus, and lung.

Mortality from TBL and larynx cancers attributable to leading risk factors

A total of 79.7% (95% UI 76.6–82.8%) of deaths from TBL cancer in Asia in 2019 were estimated to be attributable to risk factor exposure. Among the most specific GBD risks, smoking was the leading risk factor for deaths from TBL cancer, contributing to 62.0% (58.0–65.0%) of total deaths for both sexes combined and an age-standardized death rate of 16.0 (13.8–18.2) per 100,000 (Supplementary Table 4). The proportion of deaths attributable to smoking varied significantly by sex, with 78.2% (76.6–79.8%) of male deaths and 25.4% (23.2–27.3%) of female deaths from TBL cancer being attributable to smoking.

The age-standardized death rates for TBL cancer attributable to smoking in 2019 were generally highest in countries in East Asia, including China, and in Central Asia, including Armenia, Georgia, and Mongolia. China, as a country in the middle SDI quintile, had the highest number of deaths attributable to smoking among all Asian countries, with smoking contributing to 64.4% (60.2–67.9%) of total deaths from TBL cancer for both sexes combined, and an age-standardized death rate of 24.9 (20.4–29.9) per 100,000 in 2019. The proportion of deaths attributable to smoking varied significantly between the sexes in China, with 82.0% (80.6–83.5%) of male deaths and 26.6% (24.0–29.1%) of female deaths from TBL cancer being attributable to smoking. The second highest specific risk factor for TBL cancer was ambient particulate matter pollution, which accounted for 19.6% (14.8–24.3%) of deaths from TBL cancer in both sexes combined, equivalent to an age-standardized attributable death rate of 5.0 (3.7–6.5) per 100,000 in 2019.

Some countries in Central Asia, including Turkmenistan and Georgia, exhibited the highest annualized rates of increase in age-standardized death rates of TBL cancer attributable to smoking between 2010 and 2019. Among the GBD SDI quintiles, high-SDI countries such as Singapore, Japan, the Republic of Korea, and Brunei Darussalam demonstrated annualized rates of decline in age-standardized death rates of TBL cancer attributable to smoking during the same period (Supplementary Table 5).

The greatest reduction in age-standardized death rates attributed to smoking from 2010 to 2019 occurred in Singapore, which is in the high-SDI quintile, with a decrease of 23.4% (95% UI 17.6–29.6%) for both sexes combined. Age-standardized deaths attributable to smoking for TBL cancer decreased among males in all Asian regions between 2010 and 2019, similar to the global trend. However, during the same period, increases in smoking-attributable age-standardized deaths from TBL cancer were observed among females in South Asia (23.3% [−2.0 to 54.5%]) and Central Asia (5.04% [−8.0 to 18.5%]), especially in India (34.2% [2.5–72.4%]) and Kyrgyzstan (32.0% [4.7–68.9%]).

The second highest specific risk factor for TBL cancer was ambient particulate matter pollution, which accounted for 19.6% (95% UI 14.8–24.3%) of deaths from TBL cancer in both sexes combined, equivalent to an age-standardized attributable death rate of 5.0 (3.7–6.5) per 100,000 in 2019. High fasting plasma glucose was the third highest specific risk factor for deaths from TBL cancer in Asia in 2019 for both sexes combined, contributing to 7.7% (95% UI 1.7–17.1) of all deaths and 2.0% (0.5–4.4%) of age-standardized deaths per 100,000.

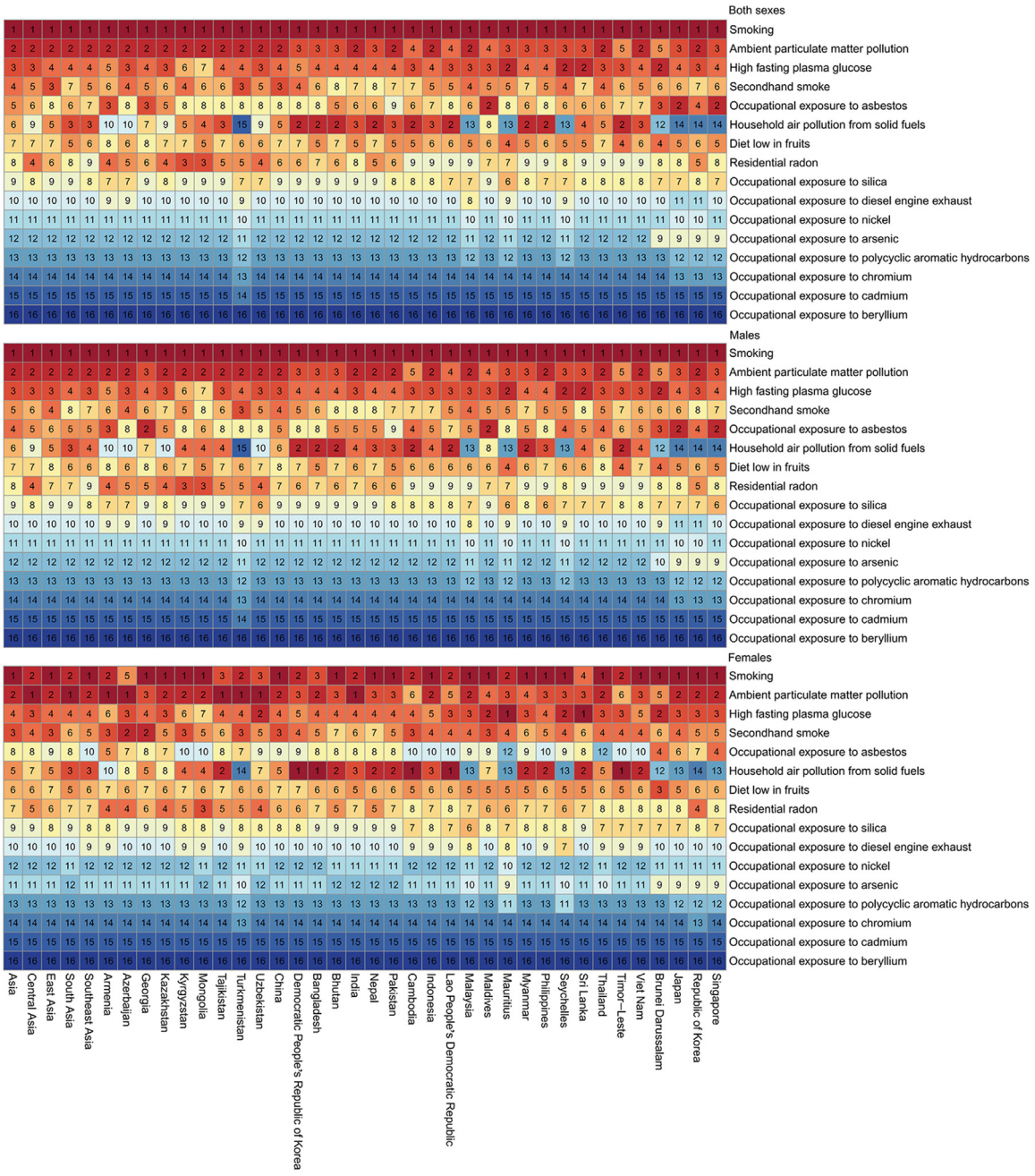

Fig. 3. Ranked contributions of risk factors to age-standardized death rate of TBL cancer by region in 2019, for both sexes combined, females, and males. Risk factors ranked from 1 (leading risk factor for age-standardized death; dark red) to 16 (lowest risk factor for age-standardized death; dark blue). TBL: Tracheal, bronchus, and lung.

There were notable regional disparities in the risk-attributable burden of TBL cancer between males and females. In Asian regions, smoking was the leading risk factor for age-standardized deaths from TBL cancer for males and both sexes combined, whereas ambient particulate matter pollution was the leading specific risk factor for females in South Asia and Central Asia (Fig. 3). Secondhand smoke was the third-leading specific risk factor for deaths from TBL cancer in females (and the fifth-leading risk factor in males). High fasting plasma glucose was the fourth-leading specific risk factor for deaths from TBL cancer in females (and the third-leading risk factor in males), while occupational exposure to asbestos was the fourth-leading specific risk factor in males in 2019 (Fig. 3).

Age-standardized death rates for TBL cancer attributable to secondhand smoke in Asia decreased between 2010 and 2019 for both sexes combined (−1.7% [−14.6 to 12.0%]) and males (−4.6% [−21.4 to 15.0%]), but increased in females (1.7% [−15.0 to 20.0%]). Central Asia and East Asia showed declines in all sexes during the same period, whereas Southeast Asia and South Asia showed non-significant increases in age-standardized death rates for TBL cancer attributable to secondhand smoke. Supplementary Table 4 provides additional information on Asia's regional and national levels.

Smoking was identified as the leading specific risk factor for larynx cancer in 2019, contributing to 62.6% (95% UI 55.5–68.5%) of all deaths from larynx cancer and 1.0 (0.8–1.1) age-standardized deaths per 100,000 population. Alcohol use and occupational exposure to sulfuric acid are ranked as the second and the third risk factor, which accounted for 15.1% (8.7–21.2%) and 3.4% (1.4–6.4%) of all deaths from larynx cancer, respectively. Among males, 70.8% (63.3–76.4%) of

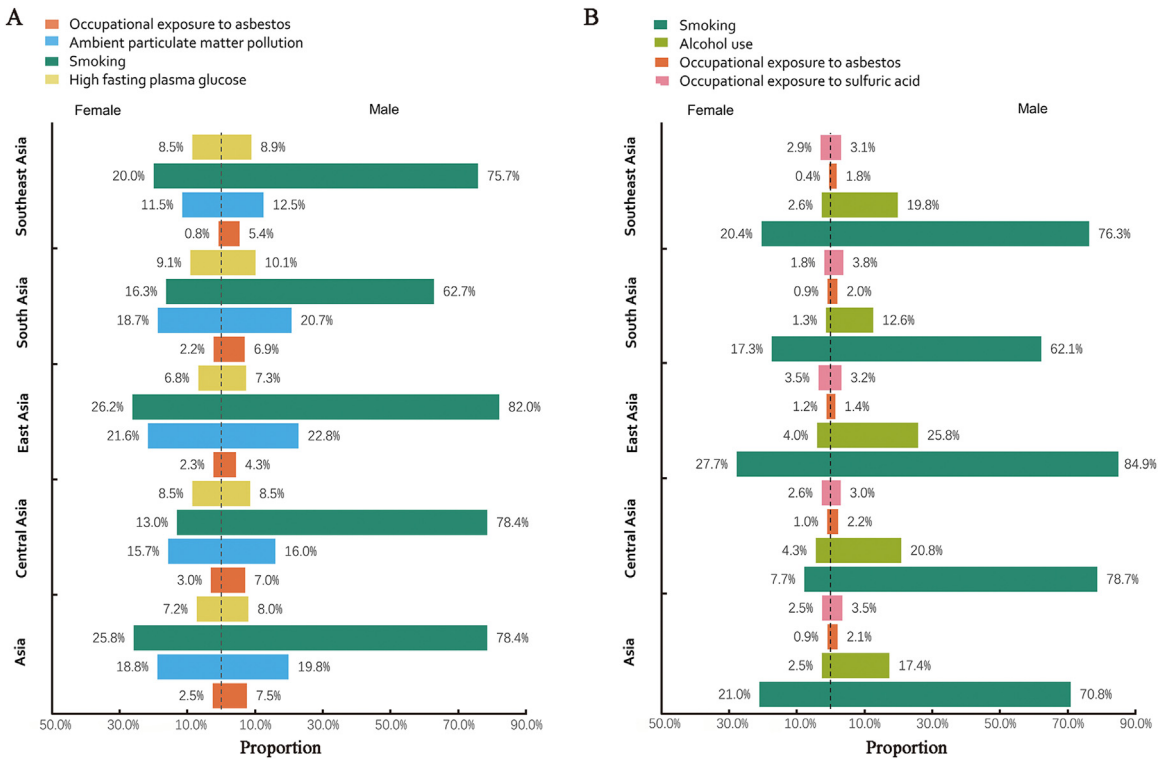

Fig. 4. Proportions of deaths attributable to leading specific risk factors by Asian area in 2019 for TBL cancer (A) and larynx cancer (B). Four leading specific risks for attributable deaths are shown for females and males. TBL: Tracheal, bronchus, and lung; UIs: Uncertainty intervals.

deaths from larynx cancer were attributable to smoking, compared with only 21.0% (15.6–24.5%) in females (Fig. 4). Country-level annualized rates of change in smoking-attributable deaths from larynx cancer and deaths from larynx cancer attributable to risk factors in Asia at the regional and national levels are summarized in Supplementary Tables 6 and 7. Proportions of deaths attributable to leading specific risk factors by Asian area in 2019 for TBL cancer and larynx cancer are shown in Fig. 4.

Discussion

Overview

In our study, the age-standardized incidence and death rates for TBL cancer in Asia declined from 2010 to 2019, while the age-standardized incidence rate of larynx cancer increased. Compared to the results from a previous GBD global study, from 2010 to 2019, the number of new TBL cancer cases increased by 23.3% globally and the number of larynx cancer cases increased by 24.7% globally. Our present results showed that the disease burden for TBL and larynx cancer in Asia was higher than the global level.[2] Global age-standardized incidence rates of TBL decreased by 7.4% and age-standardized incidence rates of larynx cancer decreased by 3.0% in males over the past decade; however, during the same period, age-standardized incidence rates in females increased by 0.9% for TBL cancer and decreased by 0.5% for larynx cancer.[2]

Unlike the global trend, larynx cancer showed an increasing age-standardized incidence rate in Asia. Smoking was the leading specific risk factor for TBL and larynx cancers in 2019 in Asia and worldwide. After adjusting for smoking and SDI, our analysis of age-standardized death, DALYs, and incidence rates for TBL cancer from 1990 to 2019 indicated that smoking and SDI were important factors influencing the disease burden, particularly in males in Central Asia based on Fig. 2.

Reducing the burden of TBL cancer in Asia

The causal link between respiratory cancer and smoking was established last century.[15] Controlling smoking is crucial for preventing respiratory cancer in Asia, and various policies such as health warnings on cigarette packages, bans on advertising, promotion, and sponsorship, as well as taxation on tobacco products, are needed to achieve this goal. Recent data from the World Health Organization indicated a significant global decrease in tobacco use over the past two decades, largely due to a reduction in the number of female smokers.[16]

Singapore, which is classified in the high-SDI quintile, exhibited the greatest decline in age-standardized death rates attributed to smoking in Asia from 2010 to 2019. Legislative measures against smoking were initiated as early as the 1970s in Singapore and have been sustained through the National Smoking Control Programme. The success of these legislative measures in Singapore can be attributed to several factors, including political will and support, early implementation of legislation, comprehensive measures, enforcement measures, and continuous review.[17]

However, legislation aimed at controlling tobacco use in developing countries has not kept pace with the dramatic rise in tobacco consumption.[7,18,19] Among the Asian regions included in the present study, East Asia had the highest age-standardized rates (death, DALYs, and incidence) for TBL cancer from 1990 to 2019. Since 2010, however, these rates have started to decline in males but have increased in females. After adjusting for smoking and SDI, there was a slow decline in these rates in all Asian regions for both sexes as compared with those before adjustment. These results demonstrate that SDI and smoking are important factors affecting the disease burden of TBL cancer. Additionally, there were significant fluctuations in deaths and incidences among males in Central Asia from 1990 to 2019 (Fig. 2). The changes in these two decades might be partially explained by the four-stage model of the cigarette epidemic, which notes a considerable lag time before the cumulative effects of smoking on health outcomes are observed.[20]

China, as a developing country that has experienced rapid development in recent decades, has made significant strides in health promotion; however, despite the decreasing age-standardized death rate, the burden of cancer remains heavy due to an aging population.[21,22] Considering the role of smoking in respiratory cancer, priority should be given to preventive measures such as smoking control. Emerging trends, such as the use of e-cigarettes and waterpipes (shisha, hookah, narghile), particularly among younger generations, pose a challenge to the control of tobacco consumption,[23] and more interventions are needed to correct the misperception that these products are substantially less harmful than tobacco cigarettes or even healthier alternatives.[24]

Ambient particulate matter pollution was the second-highest specific risk factor for TBL cancer for both sexes combined in Asia, as well as globally. Air pollution was found to be a significant risk factor for the incidence of lung cancer.[25] With the largest population, China has made extensive progress in promoting health, and likely as a result of these risk-reduction efforts, the age-standardized death rate of TBL cancer attributable to ambient particulate matter pollution in China declined from 2010 to 2019, representing one of the most significant reductions in Asia.

In addition to targeting risk factors for respiratory cancer prevention, it is also important to strengthen healthcare systems and provide effective treatment options to reduce cancer-related deaths. For instance, Health China 2030 presents an ambitious plan to control cancer in China, emphasizing the importance of early detection, diagnosis, and treatment.[22] Advances in treatment options, such as molecular agents and immunotherapies, have opened up new possibilities for patients with respiratory tract cancers. Potential new cytotoxic and molecularly targeted agents, as well as novel immunotherapeutic strategies, may further improve treatment outcomes and reduce the disease burden of these cancers in the future.

In addition to risk reduction, which remains the optimal strategy for reducing the burden of respiratory tract cancers in most populations, improving screening and subsequent early treatment could identify more patients at early stages. Low-dose computed tomography screening has been shown to prevent the greatest number of deaths from lung cancer among high-risk participants, while providing little benefit for low-risk individuals, thus supporting the risk-based targeting of smokers for such screening.[26] Screening protocols for lung cancer have been explored or implemented for certain high-risk subpopulations in China.[27] Non-coding mRNA signatures, DNA methylation, and somatic mutations that can be detected from peripheral blood are also under investigation to detect TBL cancers at early stages.[28] Policymakers should consider local risk-factor contexts when evaluating the feasibility and expansion of screening programs.

Reducing the burden of larynx cancer in Asia

Our findings regarding larynx cancer were consistent with previous global studies of the GBD database.[2,29] Smoking was identified as the highest risk factor for larynx cancer in Asia, followed by alcohol use in both sexes, with occupational exposure to sulfuric acid as the third-highest attributable risk factor. Similar to TBL cancer, reducing the burden of larynx cancer in Asia requires addressing the risk factors, improving healthcare systems and treatments, and implementing screening and early intervention measures. Our study highlights the need for expanded smoking-control programs and regulating other risk factors for larynx cancer in Asia to mitigate their impact.

Limitations and strengths

There were several limitations to this study. First, the data sources were less reliable in lower-SDI countries due to limited access to diagnostic tools. Second, genetic information was not available for patients with TBL cancer, and other risk factors beyond those provided by the GBD database were not considered. Third, the contribution of each risk factor to lung cancer may vary across different histological subtypes, and it was not possible to make this differentiation in the present study because we could not extract such information from the GBD website. Moreover, statistical records related to tracheal cancers could not be separated from those related to lung and bronchial cancers due to registration overlap in the data sources. Finally, the study inevitably carries the limitations of the GBD database, particularly in relation to the Asian data extracted. Nasopharyngeal cancer is one of the respiratory cancers. However, as this study primarily focuses on TBL and laryngeal cancers, which already account for a significant portion of the content, and given the unique nature of nasopharyngeal cancer—primarily affecting the nasopharynx and having distinct risk factors and characteristics compared to other respiratory cancers, it warrants a separate investigation. Despite these limitations, this study provides an updated Asian version of the GBD analysis of TBL and larynx cancers, highlighting differences compared with the previous global study. In addition, we used GBD data and an adjusted model to analyze the trends in disease burdens of TBL cancer in the past decades in non-smoking and non-SDI factor settings.

Conclusion

The age-standardized incidence rate for TBL cancers in Asia has exhibited a decreasing trend, similar to the global level, but the age-standardized incidence rate for larynx cancer in Asia has risen, in contrast to the global trend. The burden of TBL cancer in Asian countries from 1990 to 2019, particularly among males in Central Asia, was influenced by smoking and the SDI. There were disparities in the burdens of TBL and larynx cancers and their risk factors across different areas or countries in Asia, highlighting the need for specific cancer-control programs. We analyzed the trends in disease burdens of respiratory tract cancers over the past few decades irrespective of the influences of smoking and SDI by adjusting for these two major factors, both individually and in combination. Our systematic analysis of the burdens of respiratory tract cancers and associated risk factors at the Asian, regional, and national levels from 1990 to 2019 provides insights to help policymakers promote the early prevention and treatment of these cancers and improve public health.

Conflicts of interest

None.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.pccm.2023.11.002.

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