

The Growing Burden of Early-Onset Lung Cancer in Young Women in China: Analysis for the Global Burden of Disease Study 2021

Jianmei Song^{1,*}, Qichen Liang^{2,*}, Haixiang Wei³, Lu Ning³, Baoyu He⁴, Ziteng Zhang^{3,5}, Yanhong Meng⁶

¹Department of Operating Room, Affiliated Hospital of Jining Medical University, Jining, Shandong, 272000, People's Republic of China; ²School of Clinical Medicine, Jining Medical University, Jining, Shandong, 272000, People's Republic of China; ³Departments of Thoracic Surgery, Affiliated Hospital of Jining Medical University, Jining, Shandong, 272000, People's Republic of China; ⁴Department of Laboratory Medicine, Affiliated Hospital of Jining Medical University, Jining, Shandong, 272000, People's Republic of China; ⁵Departments of Thoracic Surgery, Qinghai Red Cross Hospital, Xining, Qinghai, 810000, People's Republic of China; ⁶Department of Ultrasonography, Affiliated Hospital of Jining Medical University, Jining, Shandong, 272000, People's Republic of China

*These authors contributed equally to this work

Correspondence: Yanhong Meng, Department of Ultrasonography, Affiliated Hospital of Jining Medical University, Jining, Shandong, 272000, People's Republic of China, Email 187297131@qq.com; Ziteng Zhang, Departments of Thoracic Surgery, Affiliated Hospital of Jining Medical University, Jining, Shandong, 272000, People's Republic of China, Email zitengzhang1353@163.com

Purpose: Using data from the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2021, this study employed a multi-level comparative approach to assess the global, regional, and national burden of early-onset lung cancer (EOLC, diagnosed before age 50) from 1990 to 2021. This design enabled the identification of distinctive epidemiological patterns. Within this framework, the primary objective was to determine and characterize the specific burden of EOLC among young women in China. A secondary objective was to evaluate the corresponding burdens in young women globally and regionally to provide essential context for interpreting the findings from China.

Patients and Methods: We used data from the Global Burden of Disease (GBD) 2021 to assess trends in EOLC incidence, mortality, disability-adjusted life years (DALYs), and attributable risk factors from 1990 to 2021. Analyses were conducted globally, regionally, and nationally for individuals under 50. Age-standardized incidence and mortality rates (ASIR and ASMR) were calculated, and Joinpoint regression was employed to evaluate temporal changes.

Results: In China, EOLC rates declined among men and the overall population but increased significantly among women beginning in 2015 (APC for incidence: +2.0%, 2015–2021). Attribution analysis showed that occupational exposures contributed an increasing share of EOLC deaths among Chinese women, rising from 7.37% in 1990 to 10.47% in 2021, compounded by persistent effects from secondhand smoke and air pollution—particularly particulate matter pollution, which accounted for 25.75% of deaths and 25.58% of DALYs in 2021. From 1990 to 2021, the global burden of EOLC remained substantial. While age-standardized incidence and mortality rates showed a declining trend, tobacco smoking persisted as the predominant risk factor, accounting for the largest proportion of attributable deaths. Marked disparities in this burden were observed across regions and between sexes.

Conclusion: The EOLC burden is shifting toward low- and middle-SDI regions. Within this transition, a distinct and rising burden among young women in China has emerged as a critical public health concern. These findings highlight the urgent need for targeted prevention strategies that address sex- and region-specific risk factors, particularly occupational and environmental exposures in rapidly developing settings.

Keywords: EOLC, global burden of disease, Chinese young woman, epidemiology, trend analysis

Introduction

Lung cancer remains the leading cause of cancer-related death globally, accounting for 12.4% of all cancer cases and 18.7% of cancer deaths.¹ Although cancer primarily affects older adults—over half of all diagnoses occur in those aged 65 or older—early-onset cancers (diagnosed before age 50) are increasingly prevalent worldwide.^{1,2} Early-onset lung

cancer (EOLC), defined as lung cancer diagnosed before age 50,³ poses a distinct public health concern for younger adults during their most productive working and family-supporting years. In this population, the disease leads to significant loss of life years, reduced economic output, and far-reaching socioeconomic consequences.

China bears one of the heaviest lung cancer burdens globally.⁴ In 2022, it recorded over 1.06 million new cases and more than 730,000 deaths, accounting for 28.5% of national cancer mortality and ranking first in both incidence and mortality.⁵ Notably, Globocan 2022 reported that 64.1% of global EOLC cases occurred in China.¹ Despite this, comprehensive analyses of EOLC in the Chinese context—especially those examining risk attribution and sex-specific patterns—remain scarce. Emerging evidence suggests a rising incidence among young Chinese women;^{6,7} however, this trend has not been thoroughly evaluated or validated through global-scale data.

Since its inception in 1991, the Global Burden of Diseases, Injuries, and Risk Factors Study has systematically tracked global health metrics.⁸ The latest edition, GBD 2021, offers detailed estimates of incidence, mortality, disability-adjusted life years (DALYs), and associated risk factors across a wide spectrum of diseases, including cancer.⁹ Data are stratified by age, sex, year, region, country, and Socio-demographic Index (SDI), supporting nuanced epidemiological assessments.¹⁰ In GBD, lung cancer encompasses malignancies of the trachea, bronchus, and lungs.

Leveraging the GBD 2021 dataset, this study was designed with a primary focus on the context of China. We investigate long-term trends (1990–2021) in early-onset lung cancer (EOLC) incidence, mortality, and DALYs, with particular emphasis on quantifying the sex-specific burden and identifying key modifiable risk factors among young women—a population exhibiting distinct risk exposures and a potentially shifting burden. To properly contextualize these national findings, a secondary objective involves examining the global and regional patterns of EOLC burden among young women, analyzing the roles of socio-demographic development and broader disparities. These analyses are critical for detecting emerging public health trends and guiding targeted, evidence-based prevention strategies.

Patients and Methods

Data Source and Screening

Data were drawn from the 2021 GBD Study, compiled by the Institute for Health Metrics and Evaluation (IHME) and accessible at <http://ghdx.healthdata.org>. The dataset encompassed global estimates from 204 countries and territories between 1990 and 2021. Lung cancer cases were identified based on ICD-9 (V16.4–V16.40, V16.1–V16.2, V10.1–V10.20, 209.21, 162–162.9) and ICD-10 codes (Z85.1–Z85.20, Z80.1–Z80.2, Z12.2, C34–C34.92, C33). EOLC was defined as diagnosis occurring between ages 15 and 49.¹¹

Incidence, mortality, prevalence, and DALYs, along with 95% uncertainty intervals (UIs), were extracted from the GBD 2021 database. Variables were disaggregated by age, sex, year, region, and SDI, which integrates per capita income, educational attainment, and fertility rate. Based on SDI, regions were categorized into five levels: low, low-middle, middle, high-middle, and high. All rates were normalized to a population of 100,000.^{12,13}

Statistical Analysis

EOLC incidence, mortality, and disability-adjusted life years (DALYs) data, along with corresponding age-standardized incidence rates (ASIR), age-standardized mortality rates (ASMR), and age-standardized DALY rates (ASDR), were extracted from the GBD 2021 study at global, regional, and national levels, with specific comparisons for China, India, and the United States. Age standardization was performed by weighting the incidence or mortality rate for each age group according to a standard population structure, thereby providing a uniform rate that removes the influence of age distribution differences on comparative results.^{14,15} The age-standardized rate (ASR) was calculated using the formula:

$$ASR = \frac{\sum_{i=1}^n (r_i \times w_i)}{\sum_{i=1}^n w_i}$$

In this context, r_i represents the incidence or mortality rate for the i -th age group and w_i denotes the weight of the corresponding age group in the standard population.

Temporal patterns were evaluated using Joinpoint Regression (version 5.2.0) to estimate annual percent change (APC) and average annual percent change (AAPC), with significant inflection points detected through segmented log-linear modeling. Log transformation was applied to address non-linearity and variance heterogeneity. For non-standardized metrics such as DALYs and prevalence, temporal and regional variations were examined using crude rates and absolute numbers.^{8,16}

Attributable burdens were estimated for six primary risk categories: tobacco use, air pollution, occupational hazards, dietary factors, residential radon, and metabolic conditions.¹³ These estimates rely on GBD 2021 modeling, which aggregates tobacco exposure (primarily smoking) but does not disaggregate e-cigarette use (vaping) due to limited data availability up to 2021. All computations and visualizations were performed in R (version 4.2.1), with statistical significance defined as $p < 0.05$.

Results

Global Trends

In 2021, an estimated 241,421 individuals (95% UI: 216,001–268,578) were living with EOLC globally, marking a 35.6% increase from 1990 (178,053 cases; 95% UI: 168,059–188,629). Despite this growth in absolute numbers, the global prevalence rate declined from 6.6 per 100,000 (95% UI: 6.2–7.0) in 1990 to 6.1 per 100,000 (95% UI: 5.5–6.8) in 2021 (Table 1 and Figure 1).

That year, EOLC resulted in 123,409 new cases (95% UI: 109,786–137,017) and 99,134 deaths (95% UI: 88,235–109,946) among individuals aged 15–49. Since 1990, incident cases rose by 18.6% and deaths by 9.5%. However, age-standardized rates declined over the same period: mortality (ASMR) fell from 4.18 (95% UI: 3.92–4.48) to 2.51 (95% UI: 2.23–2.79), and incidence (ASIR) from 4.81 (95% UI: 4.51–5.13) to 3.13 (95% UI: 2.78–3.48). The age-standardized DALY rate (ASDR) also dropped significantly, from 198.3 (95% UI: 185.28–212.38) to 119.57 (95% UI: 106.44–132.92), reflecting notable progress in mitigating the global EOLC burden.

Regional Variations

Between 1990 and 2021, the burden of EOLC showed marked variation across SDI regions. In high-SDI areas, prevalent cases declined from 58,066 (95% UI: 56,932–59,195) to 50,259 (95% UI: 48,180–52,445) (Figure 2A), with the prevalence rate decreasing from 12.6 to 10.0 per 100,000. The ASIR dropped from 6.57 (95% CI: 6.40–6.76) to 3.16 (95% CI: 3.01–3.31), corresponding to an AAPC of –2.4% (95% CI: –2.52 to –2.27). Furthermore, high-income North America experienced a 56.6% decline in incident cases, with the crude incidence rate falling from 7.7 to 2.9 per 100,000 (Figure 2B). ASIR decreased from 8.12 (95% CI: 7.87–8.37) to 2.74 (95% CI: 2.64–2.85), with an AAPC of –3.46% (95% CI: –3.68 to –3.24), reflecting effective preventive efforts.

Disparities in mortality were even more pronounced. High-SDI regions achieved a 46.6% reduction in deaths (Figure 2C), with the ASMR falling from 5.19 (95% CI: 5.06–5.33) to 2.11 (95% CI: 2.01–2.21), and an AAPC of –2.88% (95% CI: –3.10 to –2.65). Regarding the overall burden, DALYs trends further highlighted the growing inequality. Western Europe and high-income Asia Pacific achieved substantial reductions in DALYs—46.0% and 51.3%, respectively. The ASDR declined from 249.8 to 138.4 per 100,000 in Western Europe, and from 145.04 (95% CI: 134.94–157.45) to 65.65 (95% CI: 60.04–72.48) in high-income Asia Pacific, with AAPCs of –44.6% and –2.59% (95% CI: –2.88 to –2.30), respectively (Figure 2D).

Conversely, in low-SDI regions, prevalent cases rose from 2459 (95% UI: 2062–3122) to 6275 (95% UI: 5187–7633), while the prevalence rate increased only marginally (from 1.1 to 1.2 per 100,000). ASIR remained nearly unchanged, declining slightly from 1.05 (95% CI: 0.87–1.36) to 1.03 (95% CI: 0.84–1.26), with an AAPC of –0.06% (95% CI: –0.17 to 0.05). These patterns suggest that the growing burden in low-SDI regions was primarily driven by population growth rather than increased age-standardized risk. This trend was particularly evident in Central and Western Sub-Saharan Africa, where prevalent cases rose by 173.4%, yet prevalence rates remained stable (Figure 3A and B). In contrast, South Asia reported a 149.9% increase in incident cases, from 5116 (95% UI: 4462–6006) to 12,786 (95% UI: 10,978–14,815), with ASIR rising from 2.48 (95% CI: 2.13–2.91) to 2.87 (95% CI: 2.44–3.35) and an AAPC of 0.15% (95% CI: 0.07 to 0.23).

Table I Global and Regional Trends in Early-Onset Lung Cancer Burden, 1990–2021

Location	Incidence			Deaths			DALYs (Disability-Adjusted Life Years)		
	1990 (95% UI)	2021 (95% UI)	Percentage Change (%)	1990 (95% UI)	2021 (95% UI)	Percentage Change (%)	1990 (95% UI)	2021 (95% UI)	Percentage Change (%)
Number									
Global	104,060 (97,860–110,755)	123,409 (109,786–137,017)	18.6	90,525 (84,883–96,630)	99,134 (88,235–109,946)	9.5	4,361,710 (4,080,803–4,659,757)	4,721,455 (4,203,757–5,230,900)	8.2
High SDI	29,591 (29,027–30,259)	18,681 (17,939–19,412)	–36.9	23,341 (22,870–23,845)	12,455 (11,933–12,997)	–46.6	1,094,026 (1,071,588–1,117,322)	582,990 (558,640–609,008)	–46.7
High-middle SDI	36,596 (33,629–39,536)	38,839 (33,225–45,215)	6.1	32,473 (29,804–35,189)	30,419 (25,947–35,332)	–6.3	1,560,766 (1,428,782–1,692,400)	1,435,320 (1,223,873–1,665,825)	–8.0
Middle SDI	29,326 (26,345–32,665)	46,390 (39,076–53,448)	58.2	26,773 (24,042–29,819)	38,430 (32,389–44,207)	43.5	1,318,980 (1,186,074–1,469,163)	1,836,379 (1,550,959–2,108,792)	39.2
Low-middle SDI	6773 (6041–7761)	15,341 (13,826–17,181)	126.5	6291 (5622–7222)	13,999 (12,597–15,692)	122.5	308,559 (276,386–354,088)	680,284 (613,299–761,260)	120.5
Low SDI	1638 (1372–2093)	4051 (3348–4926)	147.3	1526 (1274–1944)	3743 (3088–4554)	145.2	73,674 (61,582–93,461)	182,282 (150,280–222,326)	147.4
Andean Latin America	348 (299–404)	594 (452–750)	70.9	321 (277–374)	518 (392–655)	61.2	16,315 (14,119–19,101)	25,681 (19,475–32,349)	57.4
Australasia	472 (430–514)	499 (440–571)	5.6	341 (313–369)	301 (268–337)	–11.9	15,889 (14,532–17,194)	13,961 (12,431–15,672)	–12.1
Caribbean	573 (530–621)	654 (553–764)	14.1	495 (458–533)	538 (452–634)	8.7	23,811 (22,101–25,715)	25,534 (21,472–30,069)	7.2
Central Asia	1605 (1494–1716)	1098 (964–1232)	–31.6	1464 (1361–1567)	983 (863–1105)	–32.9	71,641 (66,795–76,541)	47,692 (42,031–53,620)	–33.4
Central Europe	5702 (5455–5959)	2932 (2638–3199)	–48.6	5099 (4877–5328)	2436 (2192–2653)	–52.2	237,756 (227,292–248,305)	112,213 (101,015–122,190)	–52.8
Central Latin America	1382 (1335–1428)	1862 (1614–2142)	34.7	1268 (1225–1310)	1634 (1413–1881)	28.9	63,858 (61,728–66,046)	80,154 (69,479–92,246)	25.5
Central Sub-Saharan Africa	253 (173–387)	682 (464–1041)	169.7	235 (162–355)	631 (427–970)	168.1	11,250 (7723–16,951)	30,154 (20,415–46,113)	168.0
East Asia	36,845 (31,656–42,614)	54,415 (42,955–66,477)	47.7	33,369 (28,680–38,549)	42,069 (32,981–51,447)	26.1	1,644,186 (1,410,867–1,898,079)	1,998,988 (1,570,706–2,440,256)	21.6

Eastern Europe	8805 (8465–9172)	4468 (4009–4985)	–49.3	7626 (7348–7927)	3584 (3222–3995)	–53.0	357,068 (344,090–370,544)	167,002 (150,230–185,665)	–53.2
Eastern Sub-Saharan Africa	674 (557–886)	1497 (1239–1913)	122.0	629 (521–821)	1381 (1141–1764)	119.6	29,968 (24,837–38,928)	66,766 (55,106–85,256)	122.8
High-income Asia Pacific	3897 (3716–4099)	2646 (2439–2877)	–32.1	2951 (2813–3118)	1468 (1370–1595)	–50.2	140,849 (134,053–148,535)	68,626 (64,023–74,461)	–51.3
High-income North America	11,454 (11,162–11,721)	4975 (4817–5141)	–56.6	8749 (8521–8958)	3409 (3297–3518)	–61.0	407,776 (397,828–417,533)	159,286 (154,166–164,385)	–60.9
North Africa and Middle East	3856 (3112–4710)	7118 (6175–8274)	84.6	3604 (2912–4416)	6559 (5680–7645)	82.0	176,508 (143,452–215,181)	316,958 (276,200–368,208)	79.6
Oceania	64 (45–97)	171 (124–251)	167.2	60 (42–90)	158 (113–235)	165.6	2954 (2089–4464)	7801 (5617–11,553)	164.1
South Asia	5116 (4462–6006)	12,786 (10,978–14,815)	149.9	4749 (4139–5588)	11,603 (9954–13,512)	144.3	231,712 (201,779–272,308)	561,271 (483,291–651,588)	142.2
Southeast Asia	5786 (5148–6445)	12,779 (10,416–15,369)	120.9	5359 (4761–5978)	11,412 (9288–13,723)	113.0	262,808 (233,453–292,377)	547,738 (446,351–658,192)	108.4
Southern Latin America	1390 (1277–1499)	867 (779–965)	–37.6	1254 (1154–1351)	730 (658–809)	–41.7	59,019 (54,467–63,711)	34,942 (31,485–38,764)	–40.8
Southern Sub-Saharan Africa	812 (690–944)	1239 (1077–1412)	52.7	744 (633–864)	1124 (975–1277)	51.1	35,752 (30,436–41,364)	53,071 (46,122–60,376)	48.4
Tropical Latin America	1737 (1674–1810)	2545 (2418–2665)	46.5	1590 (1532–1657)	2239 (2128–2344)	40.8	77,078 (74,318–80,220)	107,486 (102,187–112,452)	39.5
Western Europe	13,016 (12,580–13,485)	8801 (8251–9347)	–32.4	10,363 (10,025–10,712)	5640 (5290–5979)	–45.6	483,137 (466,912–499,681)	260,855 (245,005–276,376)	–46.0
Western Sub-Saharan Africa	274 (227–326)	779 (585–1,017)	184.8	254 (211–303)	718 (541–945)	182.2	12,373 (10,251–14,752)	35,277 (26,579–46,371)	185.1
Rate									
Global	3.8 (3.6–4.1)	3.1 (2.8–3.5)	–18.6	3.3 (3.1–3.6)	2.5 (2.2–2.8)	–24.8	160.9 (150.6–171.9)	119.6 (106.5–132.5)	–25.7
High SDI	6.4 (6.3–6.6)	3.7 (3.6–3.9)	–42.1	5.1 (5–5.2)	2.5 (2.4–2.6)	–51.0	237.4 (232.5–242.4)	116.1 (111.2–121.3)	–51.1

(Continued)

Table I (Continued).

Location	Incidence			Deaths			DALYs (Disability-Adjusted Life Years)		
	1990 (95% UI)	2021 (95% UI)	Percentage Change (%)	1990 (95% UI)	2021 (95% UI)	Percentage Change (%)	1990 (95% UI)	2021 (95% UI)	Percentage Change (%)
High-middle SDI	6.5 (6–7)	6.2 (5.3–7.2)	–4.9	5.8 (5.3–6.2)	4.8 (4.1–5.6)	–16.0	276.5 (253.1–299.9)	228 (194.4–264.6)	–17.6
Middle SDI	3.2 (2.9–3.6)	3.7 (3.1–4.3)	14.8	2.9 (2.6–3.3)	3.1 (2.6–3.5)	4.1	56 (50.2–64.3)	66.9 (60.3–74.9)	19.6
Low-middle SDI	1.2 (1.1–1.4)	1.5 (1.4–1.7)	22.8	1.1 (1–1.3)	1.4 (1.2–1.5)	20.7	33.3 (27.9–42.3)	33.6 (27.7–41)	0.8
Low SDI	0.7 (0.6–0.9)	0.7 (0.6–0.9)	0.8	0.7 (0.6–0.9)	0.7 (0.6–0.8)	–0.1	87.6 (75.8–102.5)	73.4 (55.7–92.5)	–16.1
Andean Latin America	1.9 (1.6–2.2)	1.7 (1.3–2.1)	–8.9	1.7 (1.5–2)	1.5 (1.1–1.9)	–14.1	147.2 (134.7–159.3)	96.7 (86.1–108.5)	–34.3
Australasia	4.4 (4–4.8)	3.5 (3–4)	–21.1	3.2 (2.9–3.4)	2.1 (1.9–2.3)	–34.2	130.4 (121–140.8)	106.6 (89.7–125.6)	–18.2
Caribbean	3.1 (2.9–3.4)	2.7 (2.3–3.2)	–13.0	2.7 (2.5–2.9)	2.2 (1.9–2.6)	–17.1	214.8 (200.3–229.5)	97.8 (86.2–110)	–54.5
Central Asia	4.8 (4.5–5.1)	2.3 (2–2.5)	–53.2	4.4 (4.1–4.7)	2 (1.8–2.3)	–54.1	382.9 (366–399.9)	213 (191.7–231.9)	–44.4
Central Europe	9.2 (8.8–9.6)	5.6 (5–6.1)	–39.4	8.2 (7.9–8.6)	4.6 (4.2–5)	–43.7	78.2 (75.6–80.9)	60.2 (52.2–69.3)	–23.0
Central Latin America	1.7 (1.6–1.7)	1.4 (1.2–1.6)	–17.4	1.6 (1.5–1.6)	1.2 (1.1–1.4)	–21.0	46.1 (31.6–69.4)	46.2 (31.3–70.7)	0.4
Central Sub-Saharan Africa	1 (0.7–1.6)	1 (0.7–1.6)	1.0	1 (0.7–1.5)	1 (0.7–1.5)	0.4	238.7 (204.8–275.5)	290.3 (228.1–354.4)	21.6
East Asia	5.3 (4.6–6.2)	7.9 (6.2–9.7)	47.8	4.8 (4.2–5.6)	6.1 (4.8–7.5)	26.1	323.8 (312–336)	173.6 (156.1–192.9)	–46.4
Eastern Europe	8 (7.7–8.3)	4.6 (4.2–5.2)	–41.8	6.9 (6.7–7.2)	3.7 (3.3–4.2)	–46.1	35.9 (29.8–46.7)	31.9 (26.3–40.7)	–11.3
Eastern Sub-Saharan Africa	0.8 (0.7–1.1)	0.7 (0.6–0.9)	–11.6	0.8 (0.6–1)	0.7 (0.5–0.8)	–12.5	151.7 (144.4–160)	87.7 (81.9–95.2)	–42.2
High-income Asia Pacific	4.2 (4–4.4)	3.4 (3.1–3.7)	–19.4	3.2 (3–3.4)	1.9 (1.8–2)	–41.0	273.6 (267–280.2)	94.4 (91.4–97.5)	–65.5

High-income North America	7.7 (7.5–7.9)	2.9 (2.9–3)	–61.6	5.9 (5.7–6)	2 (2–2.1)	–65.6	144.8 (130.3–161.3)	146.3 (123.6–168)	1.0
North Africa and Middle East	2.4 (1.9–2.9)	2.1 (1.8–2.5)	–11.5	2.2 (1.8–2.8)	2 (1.7–2.3)	–12.7	110.1 (89.5–134.3)	94.8 (82.6–110.1)	–13.9
Oceania	2 (1.4–3)	2.4 (1.7–3.5)	20.7	1.9 (1.3–2.8)	2.2 (1.6–3.3)	19.9	92.5 (65.4–139.7)	110.3 (79.4–163.3)	19.3
South Asia	1 (0.8–1.1)	1.3 (1.1–1.5)	31.3	0.9 (0.8–1.1)	1.2 (1–1.3)	28.4	43.8 (38.1–51.5)	55.8 (48–64.7)	27.3
Southeast Asia	2.4 (2.2–2.7)	3.4 (2.8–4.1)	40.9	2.3 (2–2.5)	3.1 (2.5–3.7)	35.9	111.1 (98.7–123.6)	147.7 (120.4–177.5)	33.0
Southern Latin America	5.7 (5.2–6.1)	2.5 (2.2–2.8)	–55.9	5.1 (4.7–5.5)	2.1 (1.9–2.3)	–58.9	241 (222.4–260.1)	100.7 (90.8–111.8)	–58.2
Southern Sub-Saharan Africa	3.2 (2.7–3.7)	2.9 (2.5–3.3)	–8.9	2.9 (2.5–3.4)	2.6 (2.3–3)	–9.9	138.8 (118.2–160.6)	122.9 (106.8–139.9)	–11.4
Tropical Latin America	2.2 (2.1–2.3)	2.1 (2–2.2)	–4.0	2 (2–2.1)	1.9 (1.8–2)	–7.8	98.2 (94.6–102.2)	89.7 (85.3–93.8)	–8.6
Western Europe	6.7 (6.5–7)	4.7 (4.4–5)	–30.6	5.4 (5.2–5.5)	3 (2.8–3.2)	–44.2	249.8 (241.4–258.3)	138.4 (130–146.6)	–44.6
Western Sub-Saharan Africa	0.3 (0.3–0.4)	0.3 (0.3–0.4)	6.3	0.3 (0.2–0.4)	0.3 (0.2–0.4)	5.3	14.5 (12–17.2)	15.4 (11.6–20.2)	6.4
ASR			AAPC			AAPC			AAPC
Global	4.81 (4.51, 5.13)	3.13 (2.78, 3.48)	–1.38 (–1.53, –1.22)	4.18 (3.92, 4.48)	2.51 (2.23, 2.79)	–1.62 (–1.75, –1.49)	198.3 (185.28, 212.38)	119.57 (106.44, 132.92)	–1.62 (–1.75, –1.49)
High SDI	6.57 (6.4, 6.76)	3.16 (3.01, 3.31)	–2.4 (–2.52, –2.27)	5.19 (5.06, 5.33)	2.11 (2.01, 2.21)	–2.88 (–3.1, –2.65)	241.85 (235.65, 248.85)	99.36 (94.56, 104.38)	–2.85 (–3.07, –2.64)
High-middle SDI	7.83 (7.16, 8.51)	5.13 (4.38, 5.99)	–1.35 (–1.62, –1.08)	6.96 (6.35, 7.58)	4.02 (3.43, 4.7)	–1.78 (–2.1, –1.46)	328.85 (299.61, 359.2)	191.71 (163.26, 224.31)	–1.76 (–2.07, –1.45)
Middle SDI	4.28 (3.82, 4.82)	3.5 (2.94, 4.06)	–0.64 (–0.8, –0.48)	3.91 (3.49, 4.39)	2.9 (2.43, 3.36)	–0.94 (–1.1, –0.79)	188.02 (167.48, 211.48)	139.25 (116.57, 160.94)	–0.96 (–1.11, –0.82)
Low-middle SDI	1.62 (1.43, 1.87)	1.73 (1.54, 1.96)	0.24 (0.14, 0.34)	1.5 (1.32, 1.74)	1.58 (1.41, 1.79)	0.2 (0.14, 0.26)	72.07 (63.48, 83.48)	75.97 (67.54, 86.34)	0.19 (0.09, 0.28)

(Continued)

Table I (Continued).

Location	Incidence			Deaths			DALYs (Disability-Adjusted Life Years)		
	1990 (95% UI)	2021 (95% UI)	Percentage Change (%)	1990 (95% UI)	2021 (95% UI)	Percentage Change (%)	1990 (95% UI)	2021 (95% UI)	Percentage Change (%)
Low SDI	1.05 (0.87, 1.36)	1.03 (0.84, 1.26)	-0.06 (-0.17, 0.05)	0.97 (0.81, 1.27)	0.95 (0.78, 1.17)	-0.09 (-0.2, 0.02)	46.02 (38.02, 59.76)	45.16 (36.94, 55.58)	-0.06 (-0.18, 0.07)
High-income Asia Pacific	3.99 (3.72, 4.31)	2.49 (2.23, 2.79)	-1.62 (-1.99, -1.25)	3.03 (2.83, 3.28)	1.37 (1.26, 1.52)	-2.57 (-2.87, -2.28)	145.04 (134.94, 157.45)	65.65 (60.04, 72.48)	-2.59 (-2.88, -2.3)
Andean Latin America	2.46 (2.01, 3)	1.83 (1.36, 2.37)	-3.59 (-3.97, -3.21)	6.49 (5.96, 7)	1.59 (1.18, 2.06)	-3.65 (-4.04, -3.26)	307 (282.12, 330.78)	78.21 (57.99, 101.2)	-3.56 (-3.96, -3.16)
Australasia	4.58 (4.09, 5.09)	3.1 (2.64, 3.64)	0.09 (-0.03, 0.21)	3.1 (2.69, 3.53)	1.87 (1.64, 2.12)	-0.04 (-0.16, 0.09)	148.09 (128.36, 168.81)	86.97 (76.11, 99.35)	-0.02 (-0.15, 0.11)
Caribbean	4.05 (3.64, 4.51)	2.78 (2.32, 3.31)	-0.21 (-0.37, -0.05)	6.24 (5.29, 7.26)	2.29 (1.9, 2.73)	-0.73 (-0.89, -0.57)	300.47 (254.72, 349.84)	108.54 (90.14, 129.62)	-0.73 (-0.9, -0.56)
Central Asia	7.11 (6.53, 7.65)	2.33 (2.04, 2.64)	-2.6 (-2.79, -2.4)	8.42 (7.99, 8.86)	2.09 (1.83, 2.37)	-2.83 (-3.01, -2.66)	390.14 (369.83, 411.15)	100.59 (88.1, 14.4)	-2.82 (-2.99, -2.64)
Central Europe	9.4 (8.91, 9.92)	4.25 (3.81, 4.65)	-2.88 (-3.5, -2.26)	7.7 (7.33, 8.11)	3.52 (3.17, 3.85)	-3.05 (-3.72, -2.39)	355.91 (338.65, 374.91)	164.16 (147.52, 179.39)	-3.08 (-3.73, -2.44)
Central Latin America	2.33 (2.21, 2.45)	1.44 (1.25, 1.67)	-1.41 (-1.53, -1.28)	6.32 (4.91, 8.08)	1.27 (1.09, 1.47)	-1.45 (-1.58, -1.32)	301.22 (233.74, 384.71)	61.89 (53.39, 71.86)	-1.42 (-1.54, -1.29)
Central Sub-Saharan Africa	1.6 (1.06, 2.46)	1.47 (0.98, 2.31)	-1.27 (-1.66, -0.89)	3.32 (2.98, 3.67)	1.37 (0.9, 2.14)	-1.89 (-2.22, -1.56)	153.72 (137.82, 170.29)	64.04 (42.03, 100.38)	-1.87 (-2.18, -1.55)
East Asia	6.88 (5.83, 8.01)	6.46 (5.12, 7.94)	-1.85 (-2.03, -1.67)	5.32 (5.07, 5.58)	5 (3.95, 6.16)	-2.49 (-2.55, -2.42)	247.67 (235.79, 260.14)	241.08 (190.72, 96.57)	-2.48 (-2.55, -2.42)
Eastern Europe	8.87 (8.42, 9.38)	3.73 (3.33, 4.19)	-0.98 (-2.06, 0.11)	2.27 (1.86, 2.77)	3 (2.68, 3.36)	-1.17 (-2.23, -0.1)	111.65 (91.43, 136.12)	140.38 (125.78, 156.99)	-1.17 (-2.22, -0.1)
Eastern Sub-Saharan Africa	1.27 (1.02, 1.7)	1.04 (0.85, 1.33)	-1.18 (-1.49, -0.88)	3.5 (3.15, 3.9)	0.96 (0.78, 1.23)	-1.32 (-1.66, -0.99)	165.62 (148.83, 184.71)	45.36 (36.95, 57.97)	-1.41 (-1.8, -1.01)
High-income North America	8.12 (7.87, 8.37)	2.74 (2.64, 2.85)	-3.46 (-3.68, -3.24)	6.21 (6.02, 6.39)	1.88 (1.81, 1.95)	-3.79 (-3.97, -3.61)	287.27 (278.64, 295.84)	88.02 (84.86, 91.37)	-3.74 (-3.91, -3.58)
North Africa and Middle East	6.77 (5.24, 8.62)	4.41 (3.73, 5.23)	0.16 (0.06, 0.27)	0.42 (0.35, 0.51)	4.07 (3.44, 4.83)	0.14 (0.03, 0.24)	20.06 (16.41, 24.46)	195.59 (165.62, 31.55)	0.16 (0.06, 0.27)
Oceania	2.73 (1.81, 4.3)	2.83 (1.86, 4.38)	0.51 (0.25, 0.78)	2.3 (1.98, 2.71)	2.61 (1.71, 4.07)	0.44 (0.18, 0.71)	110.21 (94.48, 129.8)	126.85 (82.99, 197.2)	0.39 (0.16, 0.62)

South Asia	2.48 (2.13, 2.91)	2.87 (2.44, 3.35)	0.15 (0.07, 0.23)	2.54 (1.68, 3.96)	2.61 (2.21, 3.05)	0.14 (0.06, 0.21)	122.07 (80.94, 191.26)	124.82 (106.05, 146.16)	0.16 (0.08, 0.23)
Southeast Asia	3.35 (2.92, 3.81)	3.42 (2.74, 4.13)	-0.29 (-0.42, -0.17)	1.49 (0.99, 2.29)	3.05 (2.44, 3.7)	-0.31 (-0.44, -0.18)	69.55 (46.43, 106.53)	146.55 (117.08, 177.7)	-0.3 (-0.42, -0.18)
Southern Latin America	6.34 (5.55, 7.25)	2.44 (2.1, 2.83)	-1.52 (-1.81, -1.24)	2.13 (2.02, 2.24)	2.06 (1.76, 2.39)	-1.67 (-1.95, -1.38)	103.67 (98.41, 109.01)	98.49 (84.37, 114.5)	-1.64 (-1.93, -1.35)
Southern Sub-Saharan Africa	4.62 (3.85, 5.53)	3.32 (2.82, 3.89)	-2.94 (-3.13, -2.76)	5.72 (5.01, 6.55)	3.01 (2.55, 3.55)	-3.17 (-3.36, -2.98)	267.9 (234.61, 307.22)	140.75 (119.21, 65.77)	-3.1 (-3.29, -2.91)
Tropical Latin America	2.91 (2.74, 3.07)	2.04 (1.92, 2.17)	-1.15 (-1.47, -0.84)	2.66 (2.51, 2.82)	1.8 (1.69, 1.91)	-1.28 (-1.58, -0.97)	126.37 (119.2, 133.66)	86.39 (81.25, 91.9)	-1.24 (-1.54, -0.93)
Western Europe	6.68 (6.36, 7.03)	3.78 (3.5, 4.06)	-0.63 (-0.72, -0.54)	1.18 (0.95, 1.58)	2.41 (2.25, 2.58)	-0.67 (-0.76, -0.58)	55.14 (44.48, 73.54)	112.85 (105.38, 120.69)	-0.63 (-0.72, -0.54)
Western Sub-Saharan Africa	0.45 (0.37, 0.55)	0.48 (0.36, 0.62)	-0.99 (-1.4, -0.58)	4.24 (3.54, 5.09)	0.44 (0.33, 0.57)	-1.03 (-1.43, -0.62)	200.03 (166.74, 239.95)	21.07 (15.76, 27.53)	-1.03 (-1.46, -0.59)

Abbreviations: ASR, Age-Standardised Rate; AAPC, average annual percent change.

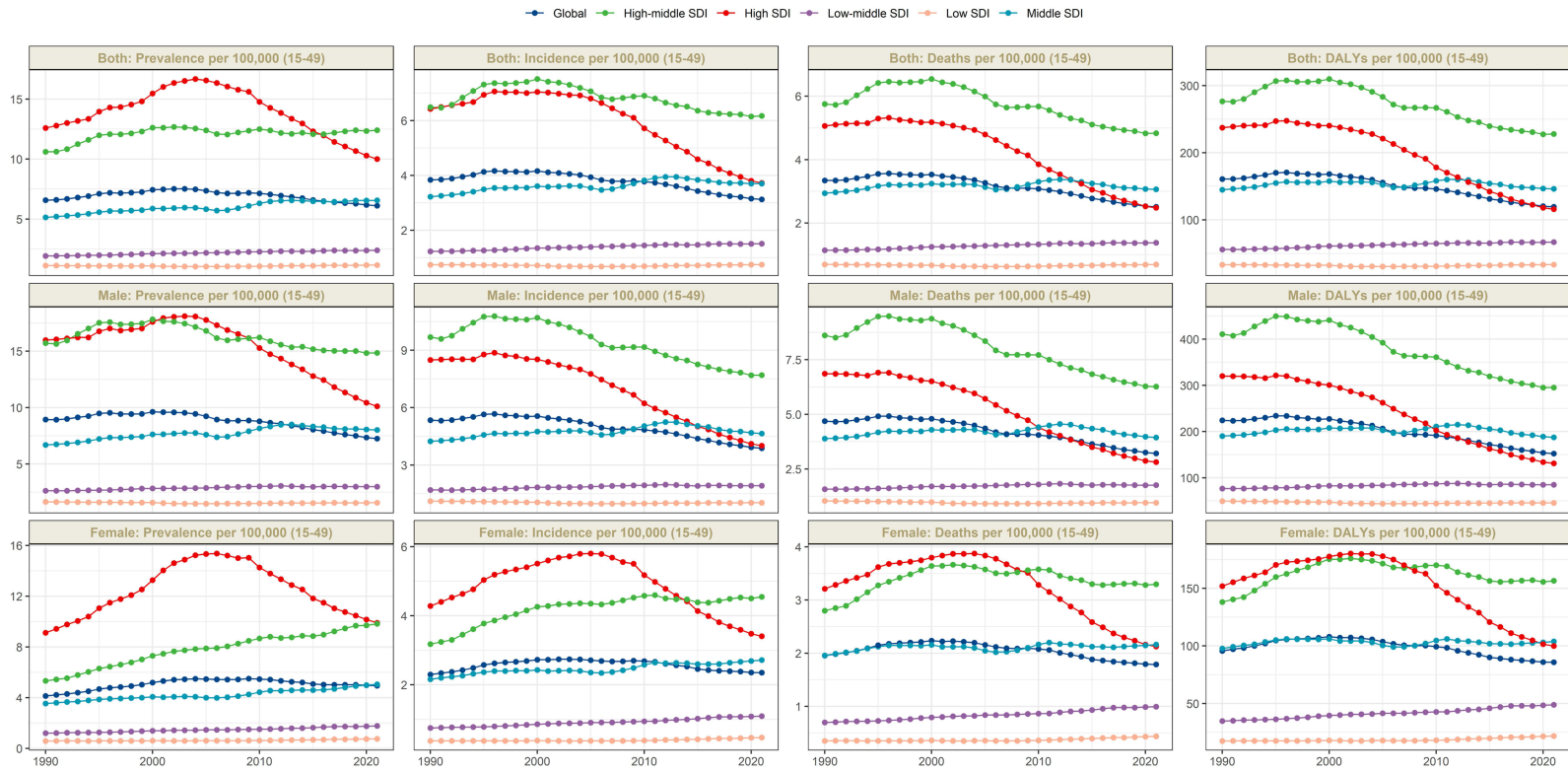


Figure 1 Global trends in early-onset lung cancer prevalence, incidence, mortality, and DALYs, 1990–2021.

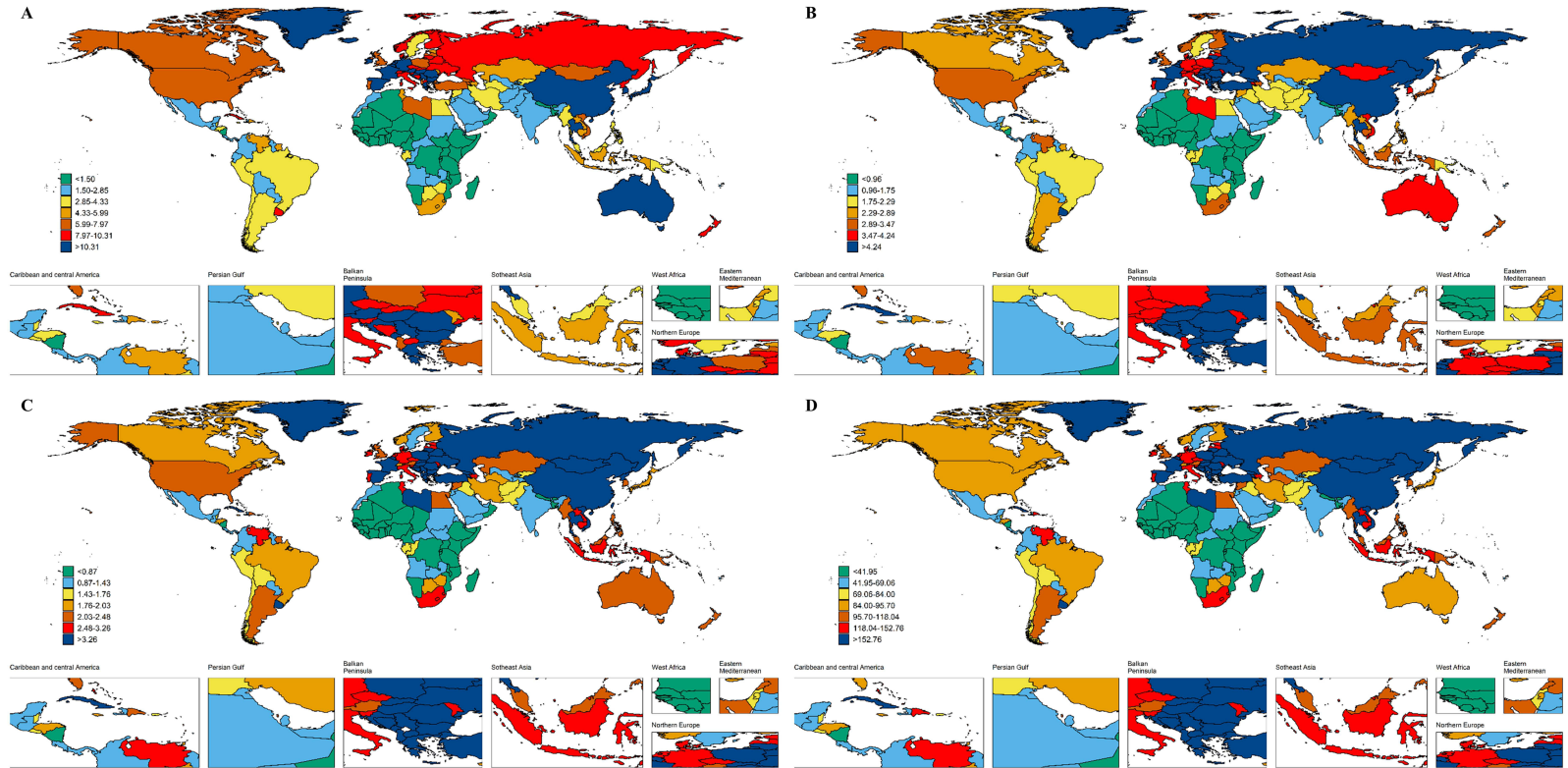


Figure 2 Global burden of early-onset lung cancer by country and territory. **(A)** Prevalence rate. **(B)** Incidence rate. **(C)** Mortality rate. **(D)** DALYs rate.

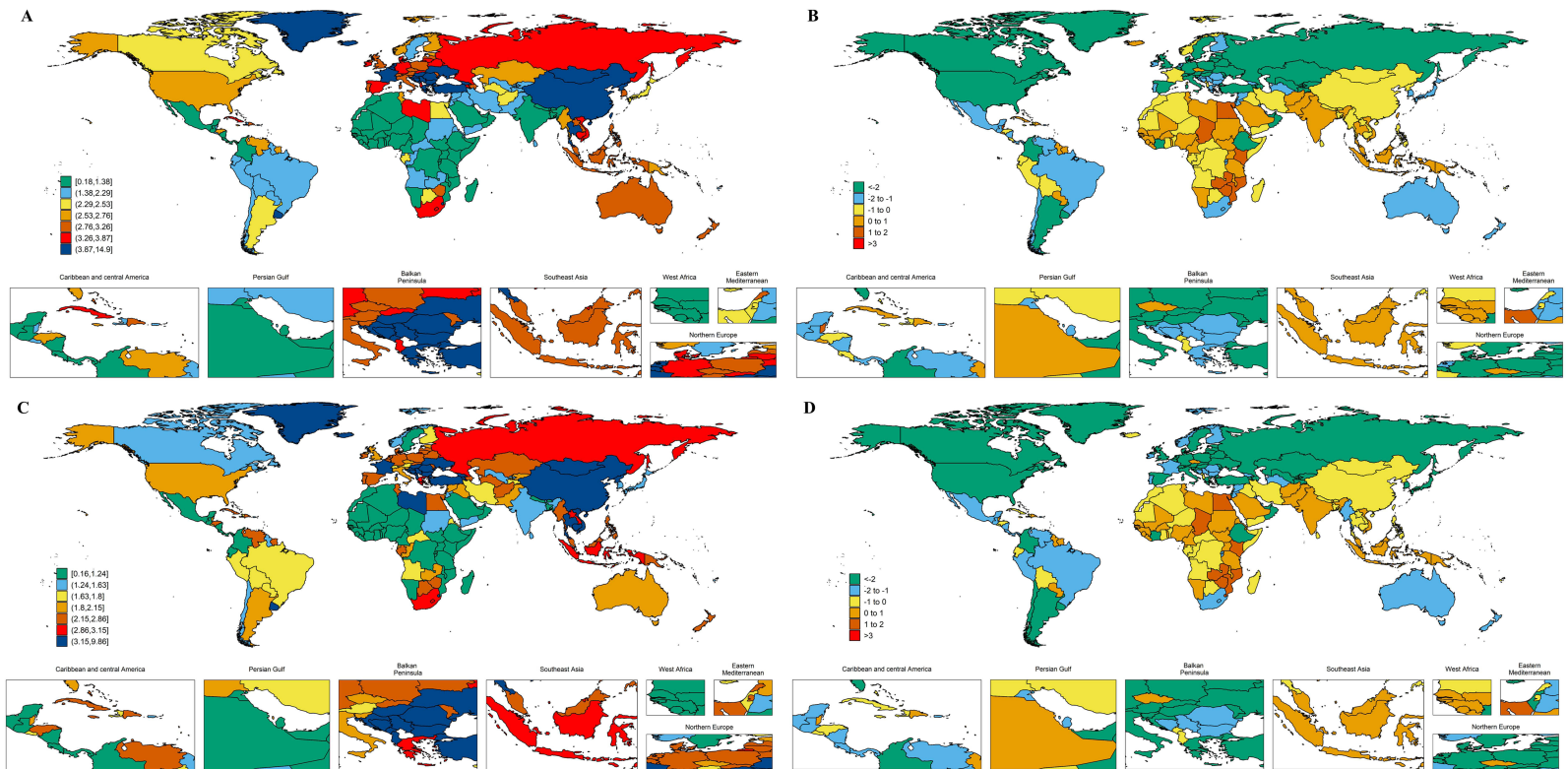


Figure 3 Global burden of early-onset lung cancer across 204 countries and territories. **(A)** ASIR; **(B)** AAPC in ASIR; **(C)** ASMR; **(D)** AAPC in ASMR.

0.23) (Figure 3A and C). Low-SDI regions saw deaths increase by 145.2%, although ASMR declined slightly from 0.97 (95% CI: 0.81–1.27) to 0.95 (95% CI: 0.78–1.17), with an AAPC of -0.09% (95% CI: -0.20 to 0.02). Notably, deaths in Central and Western Sub-Saharan Africa rose by 182.2%, with no significant change in ASMR, underscoring persistent barriers to timely diagnosis, effective treatment, and palliative care (Figure 3C and D).

In contrast, South Asia experienced a 142.2% rise in DALYs—from 231,712 (95% UI: 201,779–272,308) to 561,271 (95% UI: 483,291–651,588). ASDR also increased from 122.07 (95% CI: 80.94–191.26) to 124.82 (95% CI: 106.05–146.16), with an AAPC of 0.16% (95% CI: 0.08 to 0.23). A similar trend was observed in Southeast Asia, where DALYs rose by 108.4% and ASDR increased from 69.55 (95% CI: 46.43–106.53) to 146.55 (95% CI: 117.08–177.70), despite an AAPC of -0.30% (95% CI: -0.42 to -0.18) (Table 1). These findings underscore the widening global disparity in EOLC burden, with low-resource settings bearing an increasingly disproportionate share of health losses.

Shifting to demographic patterns, from 1990 to 2021, EOLC epidemiology underwent a significant demographic shift. While incident cases in males increased modestly by 5.7%, cases among females surged by 49.3%. High-SDI regions saw declines in both sexes (males: -47.7% ; females: -14.6%), whereas low- and middle-SDI regions experienced substantial increases, particularly among females in low-SDI areas ($+207.1\%$). Globally, the incidence rate declined by 27.4% in males but increased by 2.4% in females, with a notable 43.0% rise among females in middle-high-SDI regions (Figure 4). These trends reflect a shifting EOLC burden toward lower-SDI regions and a growing relative risk among women.

Country-Level Patterns

In 2021, ASMR for EOLC varied widely across countries. The highest rates were observed in Greenland (7.13 per 100,000; 95% UI: 4.85–9.83), Hungary (3.92; 95% UI: 3.15–4.80), and the Czech Republic (2.14; 95% UI: 1.73–2.62) (Figure 2B). Between 1990 and 2021, most countries experienced declining ASMRs, with the largest reductions in Kazakhstan (AAPC: -4.56% ; 95% CI: -4.99 to -4.12), Canada (-4.11% ; 95% CI: -4.41 to -3.82), and Estonia (-4.00% ; 95% CI: -4.87 to -3.12). In contrast, mortality rates increased in Lesotho (AAPC: $+3.57\%$; 95% CI: 3.29–3.86), Zimbabwe ($+1.84\%$; 95% CI: 1.32–2.36), and Kenya ($+1.48\%$; 95% CI: 1.32–1.63) (Table 2 and Figure 2D).

The distribution of ASIR closely followed that of ASMR. In 2021, the highest ASIRs were again reported in Greenland (8.28 per 100,000; 95% UI: 5.72–11.41), Hungary (4.79; 95% UI: 3.81–5.87), and the Czech Republic (2.87; 95% UI: 2.30–3.53) (Figure 2A). The most notable declines occurred in Kazakhstan (AAPC: -4.45% ; 95% CI: -4.88 to -4.02), Estonia (-4.04% ;

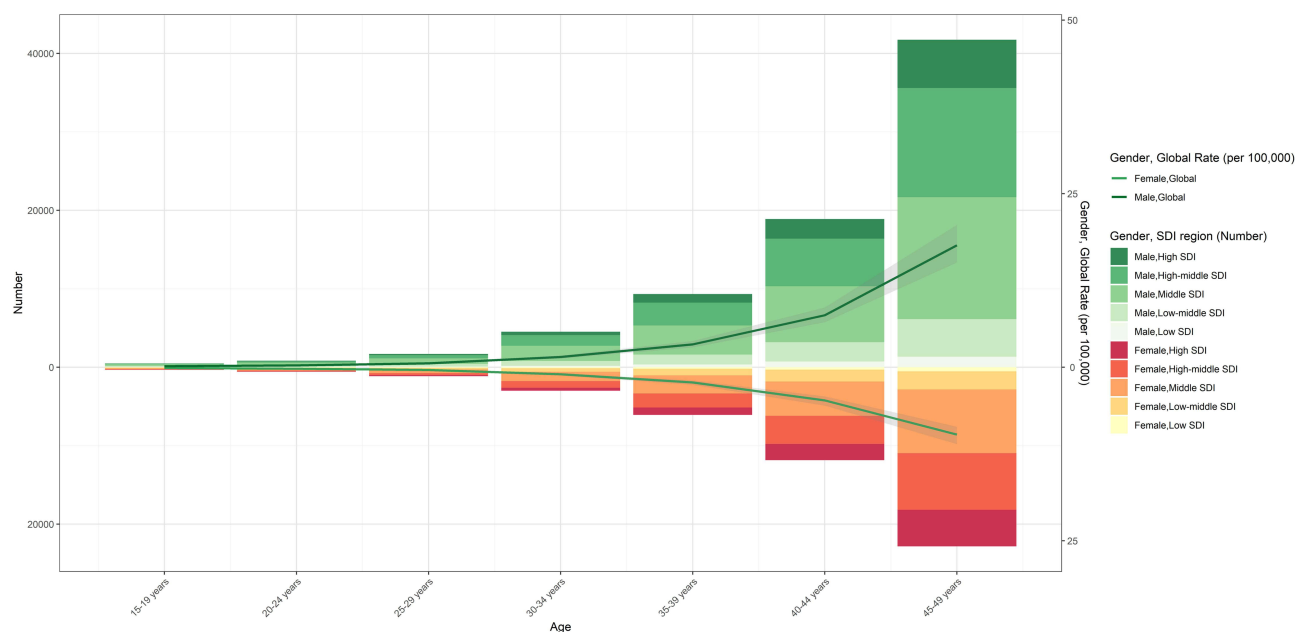


Figure 4 Age-specific incidence and case numbers of early-onset lung cancer by SDI region, 2021.

Table 2 Incidence, Mortality, and Temporal Trends of Early-Onset Lung Cancer by Region, 1990–2021

Country/Territory	Incidence				
	Cases (95% UI), 1990	ASIR (95% UI), 1990	Cases (95% UI), 2021	ASIR (95% UI), 2021	AAPC (95% CI), 1990–2021
Afghanistan	63 (31, 100)	1.86 (0.87, 3.21)	263 (156, 390)	2.33 (1.32, 3.72)	0.76 (0.65, 0.87)
Albania	50 (40, 62)	3.97 (2.97, 5.1)	49 (34, 67)	3.82 (2.62, 5.26)	-0.32 (-1.05, 0.42)
Algeria	91 (68, 116)	1.23 (0.84, 1.75)	208 (148, 290)	0.92 (0.59, 1.36)	-0.94 (-1.02, -0.85)
American Samoa	1 (1, 1)	4.72 (3.27, 6.68)	1 (1, 2)	4.73 (3.19, 6.74)	0.03 (-0.21, 0.27)
Andorra	2 (1, 3)	6.96 (4.47, 10.5)	2 (2, 4)	4.03 (2.36, 6.22)	-1.92 (-2.24, -1.59)
Angola	63 (41, 91)	1.99 (1.21, 3.1)	193 (132, 271)	1.86 (1.17, 2.78)	-0.2 (-0.65, 0.25)
Antigua and Barbuda	0 (0, 0)	1.58 (1.35, 1.85)	1 (0, 1)	1.04 (0.88, 1.21)	-0.76 (-1.63, 0.12)
Argentina	1080 (975, 1188)	7.3 (6.17, 8.6)	600 (523, 678)	2.51 (2.06, 3.01)	-3.42 (-3.93, -2.9)
Armenia	117 (109, 125)	9.6 (8.94, 10.27)	56 (49, 64)	3.66 (3.19, 4.18)	-2.94 (-3.57, -2.31)
Australia	398 (353, 441)	4.6 (4.01, 5.22)	417 (362, 487)	3.09 (2.55, 3.73)	-1.28 (-1.8, -0.76)
Austria	268 (242, 293)	6.46 (5.6, 7.46)	142 (123, 162)	2.93 (2.42, 3.55)	-2.63 (-3.27, -2)
Azerbaijan	151 (122, 185)	6.45 (5.02, 8.05)	173 (116, 246)	3.13 (2.11, 4.4)	-2.32 (-3.1, -1.52)
Bahamas	4 (3, 4)	3.61 (3.06, 4.24)	7 (5, 9)	3.26 (2.41, 4.36)	-0.37 (-0.8, 0.06)
Bahrain	7 (5, 8)	3.31 (2.41, 4.4)	22 (17, 29)	2.04 (1.41, 2.86)	-1.52 (-1.85, -1.19)
Bangladesh	443 (314, 640)	1.33 (0.83, 2.08)	791 (548, 1231)	1 (0.65, 1.62)	-0.9 (-1.23, -0.57)
Barbados	2 (2, 2)	1.8 (1.55, 2.06)	2 (2, 3)	1.42 (1.05, 1.89)	-0.67 (-1.59, 0.26)
Belarus	353 (304, 406)	7.92 (6.66, 9.33)	194 (145, 247)	3.67 (2.68, 4.78)	-2.39 (-3.37, -1.4)
Belgium	426 (386, 466)	8.78 (7.53, 10.13)	242 (213, 274)	4.09 (3.41, 4.88)	-2.67 (-2.99, -2.35)
Belize	1 (1, 1)	1.62 (1.39, 1.86)	4 (4, 5)	2.21 (1.81, 2.7)	1.12 (0.24, 2)
Benin	10 (8, 13)	0.77 (0.51, 1.09)	32 (21, 46)	0.72 (0.44, 1.14)	-0.24 (-0.39, -0.1)
Bermuda	2 (2, 2)	6.32 (5.15, 7.63)	2 (1, 2)	4.19 (3.11, 5.44)	-1.46 (-1.82, -1.09)
Bhutan	2 (1, 3)	0.97 (0.5, 1.52)	4 (2, 6)	0.96 (0.57, 1.56)	-0.07 (-0.14, 0)
Bolivia (Plurinational State of)	55 (41, 71)	2.42 (1.67, 3.36)	100 (67, 143)	1.8 (1.15, 2.67)	-0.92 (-1, -0.84)
Bosnia and Herzegovina	138 (105, 174)	6.74 (5.15, 8.56)	85 (55, 119)	4.55 (2.94, 6.35)	-1.37 (-2.06, -0.68)
Botswana	11 (7, 16)	3.01 (1.79, 4.69)	29 (19, 40)	2.41 (1.47, 3.58)	-0.71 (-1.16, -0.26)
Brazil	1715 (1653, 1788)	2.94 (2.77, 3.11)	2483 (2357, 2606)	2.05 (1.92, 2.18)	-1.18 (-1.5, -0.86)
Brunei Darussalam	5 (3, 6)	4.31 (2.96, 6.09)	10 (8, 13)	3.67 (2.65, 4.9)	-0.52 (-1.02, -0.01)
Bulgaria	427 (373, 486)	9.33 (7.85, 10.95)	265 (211, 325)	6.49 (5.1, 8.02)	-1.15 (-2.12, -0.18)
Burkina Faso	18 (13, 27)	0.66 (0.42, 1.07)	51 (34, 76)	0.7 (0.43, 1.15)	0.21 (-0.02, 0.45)
Burundi	20 (14, 30)	1.34 (0.85, 2.13)	39 (26, 60)	0.95 (0.55, 1.55)	-1.1 (-1.38, -0.82)
Cabo Verde	2 (2, 2)	2.09 (1.46, 2.88)	5 (4, 7)	1.94 (1.27, 2.95)	-0.3 (-0.79, 0.2)
Cambodia	116 (85, 160)	3.67 (2.44, 5.37)	264 (181, 379)	3.5 (2.27, 5.24)	-0.15 (-0.28, -0.03)
Cameroon	31 (24, 39)	1 (0.7, 1.4)	119 (75, 170)	1.08 (0.62, 1.64)	0.22 (0.1, 0.34)
Canada	1084 (987, 1183)	7.57 (6.68, 8.56)	479 (411, 560)	2.53 (2.09, 3.06)	-3.55 (-3.8, -3.29)
Central African Republic	18 (10, 34)	2.12 (1.17, 4.15)	38 (19, 76)	1.9 (0.93, 3.98)	-0.4 (-0.69, -0.11)

(Continued)

Table 2 (Continued).

Chad	10 (7, 14)	0.57 (0.37, 0.89)	38 (26, 56)	0.78 (0.48, 1.23)	1.19 (1.08, 1.29)
Chile	184 (156, 216)	3.19 (2.67, 3.79)	179 (145, 220)	1.82 (1.43, 2.26)	-1.71 (-2.58, -0.84)
China	35,890 (30,753, 41,673)	6.95 (5.85, 8.11)	52,901 (41,336, 65,169)	6.51 (5.1, 8.05)	-0.21 (-0.37, -0.05)
Colombia	334 (304, 366)	2.63 (2.26, 3.02)	340 (274, 416)	1.38 (1.06, 1.74)	-2.12 (-2.86, -1.38)
Comoros	2 (1, 2)	1.19 (0.71, 1.83)	4 (3, 6)	1.23 (0.74, 1.88)	-0.22 (-1.59, 1.18)
Congo	20 (12, 27)	2.89 (1.67, 4.33)	54 (34, 81)	2.2 (1.34, 3.43)	-0.86 (-1.49, -0.22)
Cook Islands	0 (0, 0)	4.7 (3.1, 6.91)	0 (0, 1)	4.49 (2.9, 6.7)	-0.16 (-0.26, -0.05)
Costa Rica	16 (14, 18)	1.44 (1.23, 1.69)	30 (26, 36)	1.24 (1.01, 1.52)	-0.78 (-1.67, 0.12)
Côte d'Ivoire	18 (14, 24)	0.51 (0.34, 0.73)	54 (36, 81)	0.52 (0.31, 0.85)	-2.16 (-3.09, -1.23)
Croatia	230 (203, 258)	9.16 (7.7, 10.69)	111 (90, 135)	4.85 (3.89, 5.91)	-1.7 (-2.11, -1.29)
Cuba	329 (298, 359)	6.37 (5.47, 7.36)	234 (189, 283)	3.8 (3.01, 4.69)	0.5 (-0.03, 1.03)
Cyprus	8 (6, 11)	2.13 (1.45, 2.99)	20 (15, 26)	2.48 (1.7, 3.44)	-3.86 (-4.4, -3.31)
Czechia	569 (496, 645)	9.86 (8.41, 11.43)	192 (155, 233)	2.87 (2.3, 3.53)	0.08 (-0.22, 0.38)
Democratic People's Republic of Korea	544 (369, 802)	5.51 (3.52, 8.37)	828 (504, 1318)	5.46 (3.11, 9.03)	-0.01 (-0.11, 0.09)
Democratic Republic of the Congo	142 (89, 229)	1.32 (0.78, 2.24)	369 (216, 655)	1.22 (0.65, 2.29)	-0.28 (-0.47, -0.09)
Denmark	243 (223, 262)	8.17 (7.18, 9.21)	98 (85, 113)	3.29 (2.74, 3.92)	-2.86 (-3.26, -2.46)
Djibouti	2 (1, 3)	1.29 (0.77, 2.03)	10 (6, 15)	1.58 (0.88, 2.65)	0.62 (0.46, 0.78)
Dominica	1 (0, 1)	2.39 (1.79, 3.14)	1 (1, 1)	2.88 (1.89, 4.19)	0.58 (0.34, 0.83)
Dominican Republic	59 (48, 72)	2.36 (1.8, 3.1)	165 (114, 228)	3.07 (2.04, 4.38)	0.97 (0.17, 1.78)
Ecuador	67 (60, 73)	1.77 (1.5, 2.08)	122 (92, 158)	1.4 (1.02, 1.89)	-0.72 (-2.25, 0.84)
Egypt	365 (303, 445)	1.7 (1.27, 2.25)	1182 (912, 1522)	2.51 (1.79, 3.44)	1.19 (0.83, 1.55)
El Salvador	33 (28, 39)	1.81 (1.44, 2.24)	56 (42, 72)	1.91 (1.37, 2.54)	0.1 (-0.9, 1.11)
Equatorial Guinea	3 (2, 4)	2 (1.12, 3.53)	11 (7, 18)	2.25 (1.29, 3.7)	0.46 (-0.37, 1.29)
Eritrea	17 (12, 25)	1.6 (1.03, 2.46)	46 (29, 71)	1.79 (1.08, 2.83)	0.34 (0.14, 0.55)
Estonia	64 (57, 72)	8.28 (7.05, 9.75)	18 (15, 22)	2.57 (2.02, 3.15)	-4.04 (-4.66, -3.42)
Eswatini	6 (4, 11)	2.86 (1.57, 5.04)	20 (10, 32)	4.51 (2.2, 7.57)	1.53 (1.18, 1.88)
Ethiopia	333 (227, 488)	2.29 (1.51, 3.5)	425 (332, 531)	1.16 (0.86, 1.49)	-2.17 (-2.29, -2.06)
Fiji	6 (4, 8)	1.81 (1.2, 2.66)	7 (4, 10)	1.47 (0.91, 2.25)	-0.68 (-0.84, -0.51)
Finland	134 (122, 147)	4.58 (3.91, 5.37)	73 (64, 82)	2.75 (2.28, 3.36)	-1.34 (-2.22, -0.45)
France	2316 (2066, 2601)	8.29 (7.17, 9.55)	2421 (2134, 2765)	7.19 (6.08, 8.45)	-0.45 (-0.63, -0.27)
Gabon	8 (5, 11)	2.62 (1.45, 4.21)	18 (12, 27)	2.44 (1.42, 3.86)	-0.13 (-0.38, 0.12)
Gambia	1 (1, 2)	0.41 (0.26, 0.62)	3 (2, 5)	0.42 (0.26, 0.68)	0.14 (-1.11, 1.4)
Georgia	177 (154, 204)	7.51 (6.47, 8.69)	81 (68, 95)	4.39 (3.67, 5.17)	-1.68 (-3.1, -0.25)
Germany	3112 (2795, 3453)	7.47 (6.41, 8.61)	1453 (1281, 1628)	3.54 (2.99, 4.14)	-2.43 (-2.81, -2.04)
Ghana	32 (23, 42)	0.65 (0.43, 0.97)	72 (51, 99)	0.53 (0.34, 0.79)	-0.69 (-0.79, -0.59)
Greece	389 (354, 426)	7.53 (6.62, 8.51)	259 (234, 286)	4.35 (3.8, 4.98)	-1.74 (-2.01, -1.47)
Greenland	5 (4, 6)	17.29 (12.72, 22.94)	2 (1, 3)	8.28 (5.72, 11.41)	-2.26 (-2.45, -2.06)

(Continued)

Table 2 (Continued).

Grenada	1 (1, 1)	2.45 (1.94, 3.02)	1 (1, 1)	1.92 (1.49, 2.45)	-0.71 (-1.74, 0.34)
Guam	3 (3, 3)	4.94 (3.86, 6.26)	5 (4, 6)	6.62 (5.17, 8.4)	0.95 (0.26, 1.66)
Guatemala	50 (47, 53)	1.89 (1.67, 2.12)	83 (70, 97)	1.22 (1, 1.47)	-1.38 (-2.49, -0.27)
Guinea	18 (14, 24)	0.96 (0.65, 1.38)	50 (33, 73)	1.21 (0.73, 1.88)	0.75 (0.57, 0.93)
Guinea-Bissau	4 (2, 5)	1.26 (0.76, 1.97)	9 (6, 12)	1.27 (0.78, 1.93)	0.04 (-0.06, 0.14)
Guyana	4 (3, 4)	1.41 (1.11, 1.76)	6 (4, 8)	1.69 (1.17, 2.34)	0.74 (0.23, 1.24)
Haiti	55 (34, 79)	2.58 (1.53, 3.88)	106 (64, 164)	1.87 (1.08, 3.13)	-0.91 (-1.03, -0.79)
Honduras	39 (31, 49)	2.7 (1.93, 3.76)	113 (68, 175)	2.68 (1.44, 4.41)	-0.02 (-0.23, 0.19)
Hungary	786 (688, 891)	13.93 (11.98, 16.08)	293 (234, 358)	4.79 (3.81, 5.87)	-3.44 (-4.09, -2.79)
Iceland	6 (5, 7)	5.31 (4.48, 6.23)	11 (9, 13)	5.93 (4.8, 7.32)	0.29 (-0.63, 1.22)
India	3917 (3407, 4551)	1.17 (1, 1.36)	9657 (8149, 11,180)	1.38 (1.15, 1.63)	0.53 (0.24, 0.82)
Indonesia	2111 (1654, 2529)	2.94 (2.28, 3.58)	5114 (3551, 7078)	3.26 (2.22, 4.49)	0.36 (0.29, 0.43)
Iran (Islamic Republic of)	345 (275, 409)	1.93 (1.54, 2.33)	932 (838, 1050)	1.83 (1.63, 2.09)	-0.24 (-0.38, -0.09)
Iraq	132 (92, 187)	2.44 (1.56, 3.66)	397 (271, 569)	2.06 (1.31, 3.09)	-0.57 (-0.76, -0.39)
Ireland	80 (72, 88)	4.95 (4.2, 5.77)	106 (91, 122)	3.7 (3.02, 4.5)	-1 (-2.07, 0.07)
Israel	79 (69, 88)	3.93 (3.35, 4.61)	108 (93, 124)	2.3 (1.93, 2.71)	-1.48 (-1.79, -1.17)
Italy	1779 (1688, 1863)	6.11 (5.73, 6.49)	978 (911, 1048)	2.83 (2.57, 3.12)	-2.45 (-2.64, -2.27)
Jamaica	26 (22, 29)	3.36 (2.69, 4.11)	37 (26, 52)	2.64 (1.76, 3.82)	-0.77 (-2.82, 1.31)
Japan	2831 (2727, 2922)	3.76 (3.58, 3.94)	1683 (1574, 1800)	2.38 (2.16, 2.63)	-1.55 (-1.97, -1.12)
Jordan	25 (19, 32)	2.39 (1.62, 3.33)	102 (76, 139)	1.7 (1.15, 2.51)	-1.01 (-1.37, -0.65)
Kazakhstan	660 (589, 735)	10.73 (9.43, 12.08)	251 (218, 285)	2.58 (2.23, 2.94)	-4.45 (-4.88, -4.02)
Kenya	20 (13, 29)	0.33 (0.22, 0.47)	98 (75, 130)	0.52 (0.4, 0.7)	1.51 (1.36, 1.66)
Kiribati	1 (1, 1)	2.81 (1.89, 4.07)	2 (1, 3)	3.45 (2.11, 5.4)	0.66 (0.56, 0.76)
Kuwait	12 (10, 14)	1.64 (1.31, 1.99)	34 (27, 44)	0.95 (0.71, 1.27)	-1.62 (-2.24, -0.99)
Kyrgyzstan	96 (82, 110)	7.14 (5.96, 8.46)	63 (49, 78)	2.04 (1.59, 2.56)	-4.23 (-4.48, -3.98)
Lao People's Democratic Republic	54 (34, 86)	4.02 (2.34, 6.65)	109 (72, 159)	3.23 (2.02, 5.05)	-0.68 (-0.78, -0.58)
Latvia	105 (92, 122)	7.73 (6.49, 9.15)	32 (25, 39)	3.19 (2.49, 3.97)	-2.96 (-4.19, -1.71)
Lebanon	41 (29, 55)	3.46 (2.34, 4.98)	80 (59, 105)	2.82 (1.95, 3.9)	-0.56 (-0.83, -0.29)
Lesotho	8 (5, 13)	1.66 (1.01, 2.79)	34 (21, 52)	4.85 (2.77, 8.1)	3.58 (3.3, 3.85)
Liberia	5 (4, 7)	0.69 (0.45, 1.05)	16 (9, 28)	0.7 (0.36, 1.27)	0.07 (-0.23, 0.36)
Libya	45 (32, 62)	3.54 (2.27, 5.42)	167 (115, 243)	3.75 (2.37, 5.78)	0.18 (0.03, 0.32)
Lithuania	135 (120, 150)	7.51 (6.36, 8.81)	51 (42, 62)	3.6 (2.79, 4.46)	-2.48 (-3.49, -1.46)
Luxembourg	15 (14, 17)	7.37 (6.43, 8.4)	12 (11, 14)	3.23 (2.71, 3.82)	-2.69 (-3.07, -2.31)
Madagascar	36 (28, 46)	1.08 (0.75, 1.49)	101 (71, 140)	0.99 (0.61, 1.49)	-0.23 (-0.33, -0.12)
Malawi	9 (7, 12)	0.33 (0.22, 0.48)	28 (20, 40)	0.45 (0.28, 0.69)	0.96 (0.71, 1.22)
Malaysia	146 (117, 182)	2.2 (1.62, 2.95)	445 (350, 570)	2.82 (2.07, 3.78)	0.92 (0.11, 1.74)
Maldives	1 (1, 2)	1.98 (1.09, 3.01)	3 (2, 4)	0.97 (0.64, 1.39)	-2.42 (-2.6, -2.23)

(Continued)

Table 2 (Continued).

Mali	16 (13, 20)	0.61 (0.43, 0.82)	43 (30, 61)	0.63 (0.41, 0.93)	0.14 (-0.05, 0.34)
Malta	6 (5, 7)	2.96 (2.41, 3.6)	8 (6, 9)	3.14 (2.5, 3.94)	0.13 (-0.54, 0.8)
Marshall Islands	1 (0, 1)	4.25 (2.65, 6.64)	2 (1, 2)	5.52 (3.03, 8.71)	0.84 (0.73, 0.95)
Mauritania	6 (4, 8)	0.94 (0.6, 1.39)	12 (8, 17)	0.79 (0.49, 1.24)	-0.59 (-0.78, -0.41)
Mauritius	11 (9, 12)	2.24 (1.95, 2.57)	12 (11, 14)	1.78 (1.51, 2.05)	-0.94 (-2.57, 0.72)
Mexico	620 (602, 639)	2.02 (1.93, 2.09)	807 (713, 913)	1.18 (1.04, 1.34)	-1.75 (-2.43, -1.05)
Micronesia (Federated States of)	2 (1, 3)	5.29 (3.22, 8.46)	3 (2, 4)	5.9 (3.41, 9.34)	0.37 (0.3, 0.44)
Monaco	2 (1, 2)	10.11 (7.26, 13.94)	3 (2, 4)	14.92 (9.6, 21.8)	1.26 (1.14, 1.38)
Mongolia	31 (24, 40)	4.7 (3.26, 6.53)	68 (52, 86)	3.94 (2.75, 5.46)	-0.63 (-1.49, 0.24)
Montenegro	27 (21, 33)	9.77 (7.57, 12.26)	28 (21, 36)	8.17 (6.04, 10.72)	-0.61 (-1.17, -0.04)
Morocco	144 (106, 194)	1.68 (1.1, 2.49)	243 (161, 373)	1.28 (0.78, 2.03)	-0.87 (-0.94, -0.81)
Mozambique	21 (15, 28)	0.49 (0.32, 0.7)	72 (47, 107)	0.77 (0.46, 1.24)	1.53 (1.38, 1.67)
Myanmar	541 (362, 747)	3.73 (2.35, 5.57)	772 (537, 1112)	2.76 (1.79, 4.08)	-0.96 (-1.05, -0.88)
Namibia	4 (3, 5)	0.94 (0.65, 1.3)	11 (7, 16)	1.08 (0.65, 1.64)	0.54 (0.14, 0.95)
Nauru	0 (0, 0)	7.69 (3.7, 11.98)	0 (0, 1)	8.12 (3.81, 12.09)	0.17 (0.1, 0.25)
Nepal	73 (48, 107)	1.08 (0.65, 1.71)	140 (96, 206)	1.03 (0.64, 1.61)	-0.13 (-0.33, 0.08)
Netherlands	575 (532, 619)	7.14 (6.28, 8.13)	365 (326, 411)	4.28 (3.66, 5.01)	-1.6 (-1.84, -1.37)
New Zealand	75 (67, 82)	4.49 (3.97, 5.06)	82 (72, 92)	3.18 (2.74, 3.65)	-1.19 (-1.65, -0.72)
Nicaragua	12 (10, 14)	1.03 (0.77, 1.32)	25 (20, 32)	0.81 (0.56, 1.12)	-1.05 (-1.47, -0.62)
Niger	12 (8, 19)	0.52 (0.33, 0.84)	29 (18, 50)	0.45 (0.26, 0.82)	-0.45 (-0.68, -0.21)
Nigeria	50 (35, 68)	0.17 (0.12, 0.24)	134 (89, 183)	0.18 (0.12, 0.25)	0.05 (-0.06, 0.16)
Niue	0 (0, 0)	3.66 (2.31, 5.63)	0 (0, 0)	4.18 (2.55, 6.56)	0.43 (0.12, 0.74)
North Macedonia	63 (49, 77)	6.61 (5.06, 8.32)	61 (44, 82)	4.61 (3.31, 6.15)	-0.98 (-1.5, -0.47)
Northern Mariana Islands	2 (1, 3)	7.58 (4.69, 11.46)	1 (1, 2)	5.25 (3.64, 7.51)	-1.2 (-1.38, -1.02)
Norway	79 (75, 84)	3.6 (3.33, 3.88)	76 (69, 83)	2.61 (2.3, 2.96)	-0.9 (-1.27, -0.54)
Oman	5 (3, 8)	0.75 (0.44, 1.18)	12 (8, 17)	0.42 (0.27, 0.65)	-2.03 (-2.44, -1.62)
Pakistan	682 (536, 835)	1.89 (1.42, 2.45)	2195 (1638, 2926)	2.29 (1.62, 3.15)	0.61 (0.49, 0.74)
Palau	1 (0, 1)	7.7 (5.11, 11.35)	1 (1, 1)	8.09 (5.61, 11.4)	0.14 (-0.19, 0.48)
Palestine	17 (12, 24)	3.08 (1.92, 4.72)	49 (39, 63)	2.42 (1.71, 3.34)	-0.83 (-1.12, -0.53)
Panama	19 (18, 21)	2.04 (1.78, 2.3)	26 (20, 32)	1.25 (0.96, 1.58)	-1.47 (-2.42, -0.51)
Papua New Guinea	36 (22, 62)	2.5 (1.35, 4.67)	117 (73, 188)	2.61 (1.42, 4.57)	0.15 (0.06, 0.24)
Paraguay	22 (18, 27)	1.58 (1.17, 2.11)	62 (45, 84)	1.88 (1.27, 2.69)	0.77 (0.42, 1.11)
Peru	226 (185, 278)	2.79 (2.08, 3.62)	372 (259, 495)	2.03 (1.37, 2.86)	-0.98 (-2.78, 0.85)
Philippines	799 (710, 897)	3.52 (3.08, 4.02)	1569 (1282, 1844)	2.97 (2.42, 3.55)	-0.59 (-0.71, -0.47)
Poland	1666 (1608, 1726)	9.57 (9.14, 10)	706 (643, 771)	3.11 (2.81, 3.41)	-3.78 (-4.12, -3.44)
Portugal	212 (190, 238)	4.38 (3.7, 5.19)	184 (161, 210)	2.89 (2.41, 3.43)	-1.29 (-2.02, -0.57)
Puerto Rico	53 (47, 60)	3.08 (2.59, 3.66)	37 (29, 46)	2.2 (1.64, 2.85)	-1.26 (-1.43, -1.09)

(Continued)

Table 2 (Continued).

Qatar	5 (4, 7)	2.11 (1.41, 3.05)	27 (20, 38)	1.24 (0.8, 1.88)	-1.78 (-3.08, -0.46)
Republic of Korea	1002 (830, 1188)	4.8 (3.73, 6.07)	876 (715, 1087)	2.77 (2.12, 3.62)	-1.8 (-2.04, -1.56)
Republic of Moldova	143 (128, 158)	7.39 (6.39, 8.5)	64 (54, 74)	2.9 (2.38, 3.49)	-2.96 (-4.51, -1.39)
Romania	907 (771, 1059)	8.4 (7.02, 10.01)	616 (494, 745)	5.38 (4.28, 6.58)	-1.39 (-1.81, -0.97)
Russian Federation	5382 (5242, 5514)	8.36 (8.07, 8.64)	3022 (2735, 3278)	3.62 (3.28, 3.94)	-2.61 (-3.39, -1.83)
Rwanda	30 (21, 41)	1.61 (1.04, 2.37)	57 (37, 87)	1.16 (0.67, 1.87)	-1.08 (-1.39, -0.77)
Saint Kitts and Nevis	0 (0, 0)	2.33 (1.98, 2.71)	0 (0, 1)	1.26 (0.91, 1.67)	-1.93 (-2.22, -1.64)
Saint Lucia	1 (1, 1)	2.91 (2.52, 3.36)	2 (2, 3)	2.22 (1.72, 2.81)	-0.88 (-1.41, -0.36)
Saint Vincent and the Grenadines	1 (1, 1)	1.99 (1.68, 2.31)	1 (1, 2)	2.09 (1.7, 2.55)	0.12 (-0.2, 0.44)
Samoa	1 (0, 1)	1.15 (0.75, 1.72)	1 (1, 2)	1.34 (0.82, 2.01)	0.48 (0.39, 0.58)
San Marino	1 (1, 1)	5.43 (3.94, 7.18)	1 (0, 1)	3.2 (1.66, 5.19)	-1.88 (-2.04, -1.73)
Sao Tome and Principe	1 (0, 1)	1.62 (1.07, 2.31)	2 (1, 3)	1.96 (1.13, 3.29)	0.54 (-0.06, 1.15)
Saudi Arabia	55 (38, 74)	0.97 (0.61, 1.46)	266 (183, 372)	0.99 (0.63, 1.48)	0.07 (-0.08, 0.22)
Senegal	20 (15, 28)	0.94 (0.62, 1.4)	52 (37, 74)	0.94 (0.58, 1.47)	0.05 (-0.24, 0.33)
Serbia	453 (354, 585)	9.42 (6.91, 12.65)	326 (244, 421)	6.43 (4.58, 8.66)	-1.13 (-1.54, -0.71)
Seychelles	1 (1, 1)	3.47 (2.52, 4.75)	1 (1, 2)	2.39 (1.68, 3.29)	-1.08 (-1.66, -0.49)
Sierra Leone	10 (7, 14)	0.75 (0.48, 1.18)	24 (15, 36)	0.78 (0.45, 1.25)	0.13 (-0.07, 0.33)
Singapore	60 (53, 67)	3.65 (3.1, 4.28)	77 (66, 91)	2.04 (1.62, 2.55)	-1.74 (-2.66, -0.81)
Slovakia	223 (175, 275)	8.93 (6.49, 11.72)	123 (91, 159)	3.62 (2.48, 4.92)	-2.92 (-3.67, -2.16)
Slovenia	73 (64, 83)	7.17 (6.13, 8.29)	34 (26, 44)	2.91 (2.21, 3.76)	-2.72 (-3.56, -1.89)
Solomon Islands	5 (3, 7)	4.58 (2.27, 7.5)	16 (11, 23)	5.58 (3.65, 8.14)	0.65 (0.53, 0.76)
Somalia	25 (15, 46)	1.03 (0.56, 2.02)	66 (35, 140)	0.98 (0.47, 2.15)	-0.17 (-0.26, -0.07)
South Africa	737 (625, 867)	5.56 (4.58, 6.76)	984 (855, 1131)	3.48 (2.93, 4.14)	-1.5 (-1.97, -1.02)
South Sudan	18 (11, 27)	1.11 (0.62, 1.8)	42 (28, 63)	1.23 (0.76, 1.92)	0.4 (0, 0.8)
Spain	1371 (1238, 1513)	7.47 (6.38, 8.71)	1037 (891, 1195)	3.53 (2.92, 4.18)	-2.47 (-2.73, -2.22)
Sri Lanka	134 (106, 171)	1.77 (1.28, 2.48)	179 (113, 255)	1.55 (0.91, 2.34)	-0.36 (-1, 0.27)
Sudan	104 (69, 161)	1.59 (0.97, 2.66)	278 (169, 424)	1.63 (0.93, 2.59)	0.08 (-0.04, 0.2)
Suriname	4 (3, 5)	2.57 (1.79, 3.47)	8 (6, 11)	2.74 (1.81, 3.96)	0.32 (-1.18, 1.84)
Sweden	159 (144, 174)	3.2 (2.8, 3.66)	80 (69, 93)	1.56 (1.27, 1.9)	-2.42 (-2.93, -1.91)
Switzerland	214 (191, 238)	5.42 (4.58, 6.35)	140 (121, 158)	2.88 (2.35, 3.5)	-2.13 (-3.01, -1.24)
Syrian Arab Republic	118 (87, 155)	3.14 (2.16, 4.35)	171 (116, 242)	2.26 (1.47, 3.27)	-1.16 (-1.33, -1)
Taiwan (Province of China)	411 (373, 453)	4.57 (3.96, 5.24)	686 (592, 785)	4.7 (3.9, 5.58)	0.04 (-0.31, 0.4)
Tajikistan	65 (49, 83)	4.51 (3.34, 6)	78 (49, 121)	1.8 (1.11, 2.84)	-2.95 (-3.14, -2.76)
Thailand	1266 (1028, 1551)	5.2 (3.83, 6.91)	2149 (1572, 2897)	5.42 (3.74, 7.7)	0.14 (-0.27, 0.56)
Timor-Leste	5 (3, 8)	1.87 (1.13, 2.93)	10 (7, 15)	2.02 (1.28, 3.01)	0.29 (-0.16, 0.74)
Togo	9 (6, 12)	0.85 (0.54, 1.27)	33 (19, 50)	0.99 (0.54, 1.65)	0.52 (0.15, 0.89)
Tokelau	0 (0, 0)	3.08 (1.97, 4.72)	0 (0, 0)	3.83 (2.42, 5.84)	0.77 (0.59, 0.94)

(Continued)

Table 2 (Continued).

Tonga	1 (1, 2)	3.93 (2.68, 5.57)	2 (1, 3)	4.35 (2.66, 6.71)	0.32 (0.11, 0.53)
Trinidad and Tobago	11 (10, 12)	2.21 (1.92, 2.54)	16 (11, 21)	2.03 (1.47, 2.71)	-0.12 (-1.17, 0.94)
Tunisia	68 (52, 86)	2.43 (1.67, 3.42)	177 (116, 250)	2.66 (1.62, 4.03)	0.28 (0.12, 0.44)
Turkey	2120 (1546, 2802)	9.9 (6.7, 13.96)	2191 (1653, 2783)	4.64 (3.24, 6.31)	-2.53 (-2.89, -2.17)
Turkmenistan	44 (40, 48)	4.02 (3.57, 4.47)	59 (44, 79)	2.4 (1.8, 3.21)	-1.45 (-2.52, -0.38)
Tuvalu	0 (0, 0)	3.72 (2.27, 5.97)	0 (0, 0)	4.49 (2.75, 6.9)	0.62 (0.56, 0.69)
Uganda	37 (27, 50)	0.84 (0.57, 1.22)	141 (93, 198)	1.11 (0.68, 1.67)	0.9 (0.73, 1.06)
Ukraine	2623 (2343, 2959)	10.68 (9.08, 12.58)	1086 (702, 1541)	4.24 (2.74, 6.18)	-3.07 (-3.65, -2.49)
United Arab Emirates	23 (15, 34)	2.5 (1.52, 3.85)	99 (68, 151)	1.04 (0.67, 1.63)	-2.81 (-3.25, -2.36)
United Kingdom	1531 (1501, 1562)	5.22 (5.09, 5.35)	976 (944, 1006)	2.83 (2.71, 2.94)	-2.03 (-2.44, -1.61)
United Republic of Tanzania	76 (56, 108)	1.07 (0.73, 1.61)	233 (159, 331)	1.14 (0.73, 1.76)	0.2 (0.03, 0.36)
United States of America	10,365 (10,108, 10,601)	8.18 (7.93, 8.43)	4494 (4342, 4657)	2.76 (2.66, 2.88)	-3.46 (-3.69, -3.23)
United States Virgin Islands	2 (2, 3)	3.51 (2.53, 4.73)	1 (1, 2)	3.54 (2.31, 5.3)	0.13 (-0.21, 0.47)
Uruguay	126 (111, 142)	8.92 (7.54, 10.4)	88 (73, 105)	5.02 (4.08, 6.08)	-2.01 (-2.29, -1.73)
Uzbekistan	263 (237, 292)	4.32 (3.71, 4.96)	269 (222, 325)	1.56 (1.24, 1.95)	-3.16 (-4.91, -1.37)
Vanuatu	1 (1, 3)	2.91 (1.47, 5.62)	4 (3, 7)	3.28 (1.84, 5.8)	0.36 (0.24, 0.49)
Venezuela (Bolivarian Republic of)	258 (239, 279)	3.76 (3.31, 4.23)	382 (278, 509)	2.63 (1.88, 3.58)	-1.15 (-1.58, -0.73)
Viet Nam	595 (427, 800)	3.07 (2.03, 4.41)	2133 (1533, 2946)	3.87 (2.56, 5.73)	0.76 (0.68, 0.85)
Yemen	67 (37, 121)	1.85 (0.98, 3.37)	210 (118, 362)	1.69 (0.9, 2.99)	-0.33 (-0.53, -0.13)
Zambia	28 (22, 36)	1.3 (0.92, 1.82)	133 (83, 269)	2.01 (1.15, 4.24)	1.42 (1.26, 1.57)
Zimbabwe	45 (35, 56)	1.62 (1.15, 2.19)	162 (108, 236)	2.79 (1.78, 4.23)	1.84 (1.3, 2.38)
Death					
Country/Territory	Cases (95%UI), 1990	ASMR (95% UI), 1990	Cases (95%UI), 2021	ASMR (95% UI), 2021	AAPC (95% CI), 1990-2021
Afghanistan	60 (29, 95)	1.74 (0.83, 3.05)	247 (147, 365)	2.18 (1.24, 3.52)	0.76 (0.64, 0.88)
Albania	46 (36, 57)	3.62 (2.71, 4.63)	41 (29, 56)	3.23 (2.24, 4.45)	-0.49 (-1.46, 0.49)
Algeria	85 (63, 109)	1.15 (0.77, 1.63)	191 (135, 268)	0.84 (0.55, 1.25)	-0.98 (-1.06, -0.9)
American Samoa	1 (1, 1)	4.36 (2.98, 6.2)	1 (1, 1)	4.28 (2.87, 6.06)	-0.03 (-0.27, 0.21)
Andorra	2 (1, 2)	5.46 (3.45, 8.31)	2 (1, 3)	2.67 (1.64, 4.13)	-2.49 (-2.95, -2.02)
Angola	59 (39, 86)	1.86 (1.15, 2.89)	178 (121, 256)	1.72 (1.08, 2.58)	-0.23 (-0.69, 0.22)
Antigua and Barbuda	0 (0, 0)	1.38 (1.18, 1.62)	0 (0, 0)	0.85 (0.72, 0.99)	-0.95 (-1.82, -0.08)
Argentina	976 (878, 1076)	6.6 (5.58, 7.76)	514 (450, 580)	2.15 (1.77, 2.58)	-3.58 (-4.1, -3.06)
Armenia	106 (98, 113)	8.71 (8.06, 9.33)	49 (43, 56)	3.2 (2.8, 3.65)	-3.05 (-3.69, -2.41)
Australia	281 (251, 309)	3.26 (2.84, 3.68)	245 (215, 280)	1.81 (1.54, 2.12)	-1.77 (-2.35, -1.18)
Austria	211 (192, 230)	5.06 (4.41, 5.82)	86 (77, 97)	1.77 (1.5, 2.09)	-3.52 (-4.14, -2.89)
Azerbaijan	139 (113, 170)	5.93 (4.68, 7.43)	155 (103, 220)	2.81 (1.87, 3.93)	-2.38 (-3.25, -1.52)
Bahamas	3 (3, 4)	3.19 (2.71, 3.74)	6 (5, 8)	2.75 (2.07, 3.71)	-0.42 (-1.15, 0.32)
Bahrain	6 (5, 8)	3.09 (2.26, 4.1)	20 (15, 27)	1.86 (1.29, 2.63)	-1.6 (-1.92, -1.27)

(Continued)

Table 2 (Continued).

Bangladesh	412 (293, 598)	1.24 (0.78, 1.95)	716 (490, 1120)	0.91 (0.59, 1.48)	-0.99 (-1.32, -0.66)
Barbados	2 (2, 2)	1.56 (1.35, 1.78)	2 (1, 2)	1.15 (0.85, 1.53)	-0.9 (-1.82, 0.02)
Belarus	312 (269, 356)	7 (5.87, 8.16)	151 (112, 191)	2.86 (2.07, 3.69)	-2.78 (-3.75, -1.8)
Belgium	344 (313, 376)	7.11 (6.11, 8.13)	164 (146, 183)	2.77 (2.34, 3.26)	-3.25 (-3.57, -2.93)
Belize	1 (1, 1)	1.45 (1.26, 1.67)	4 (3, 5)	1.9 (1.54, 2.32)	0.99 (0.11, 1.88)
Benin	10 (7, 12)	0.71 (0.48, 1.01)	29 (20, 43)	0.67 (0.41, 1.06)	-0.27 (-0.42, -0.13)
Bermuda	2 (1, 2)	5.25 (4.32, 6.33)	1 (1, 1)	2.64 (1.97, 3.36)	-2.36 (-2.7, -2.01)
Bhutan	2 (1, 3)	0.9 (0.47, 1.41)	3 (2, 5)	0.88 (0.51, 1.4)	-0.15 (-0.22, -0.08)
Bolivia (Plurinational State of)	51 (38, 66)	2.25 (1.55, 3.16)	91 (61, 130)	1.64 (1.03, 2.44)	-0.99 (-1.06, -0.91)
Bosnia and Herzegovina	124 (95, 157)	6.08 (4.67, 7.74)	73 (47, 101)	3.87 (2.5, 5.4)	-1.79 (-2.46, -1.12)
Botswana	10 (7, 15)	2.79 (1.68, 4.37)	26 (17, 36)	2.2 (1.37, 3.25)	-0.75 (-1.19, -0.31)
Brazil	1570 (1513, 1638)	2.69 (2.54, 2.85)	2184 (2070, 2293)	1.8 (1.69, 1.92)	-1.3 (-1.61, -1)
Brunei Darussalam	4 (3, 5)	3.83 (2.64, 5.39)	8 (6, 10)	3.03 (2.2, 4.03)	-0.76 (-1.26, -0.26)
Bulgaria	382 (333, 435)	8.35 (7.03, 9.79)	228 (183, 277)	5.57 (4.44, 6.81)	-1.28 (-2.28, -0.26)
Burkina Faso	17 (12, 25)	0.61 (0.39, 1)	47 (32, 71)	0.65 (0.4, 1.06)	0.2 (-0.04, 0.44)
Burundi	19 (13, 28)	1.25 (0.79, 1.96)	37 (24, 56)	0.88 (0.52, 1.46)	-1.11 (-1.39, -0.84)
Cabo Verde	2 (1, 2)	1.91 (1.34, 2.63)	5 (3, 7)	1.73 (1.12, 2.64)	-0.38 (-0.87, 0.12)
Cambodia	109 (79, 150)	3.43 (2.27, 5.11)	241 (166, 347)	3.2 (2.09, 4.79)	-0.22 (-0.34, -0.09)
Cameroon	29 (22, 36)	0.93 (0.65, 1.3)	110 (67, 157)	0.99 (0.57, 1.53)	0.19 (0.08, 0.31)
Canada	833 (761, 899)	5.83 (5.16, 6.48)	309 (267, 356)	1.63 (1.38, 1.94)	-4.11 (-4.41, -3.82)
Central African Republic	17 (10, 32)	1.98 (1.11, 3.87)	35 (18, 71)	1.77 (0.85, 3.7)	-0.4 (-0.69, -0.11)
Chad	9 (6, 13)	0.53 (0.34, 0.83)	35 (24, 52)	0.73 (0.45, 1.14)	1.17 (1.06, 1.27)
Chile	165 (140, 195)	2.87 (2.41, 3.41)	142 (115, 175)	1.44 (1.15, 1.79)	-2.14 (-3.14, -1.14)
China	32,520 (27,890, 37,748)	6.3 (5.31, 7.35)	40,816 (31,721, 50,083)	5.03 (3.92, 6.23)	-0.74 (-0.9, -0.58)
Colombia	307 (279, 336)	2.4 (2.07, 2.77)	289 (233, 355)	1.17 (0.9, 1.49)	-2.35 (-3.09, -1.6)
Comoros	2 (1, 2)	1.11 (0.66, 1.67)	4 (2, 5)	1.14 (0.68, 1.73)	0 (-1.05, 1.05)
Congo	18 (11, 25)	2.7 (1.56, 4.05)	49 (31, 76)	2.03 (1.23, 3.21)	-0.79 (-1.4, -0.18)
Cook Islands	0 (0, 0)	4.3 (2.91, 6.28)	0 (0, 0)	3.82 (2.51, 5.74)	-0.39 (-0.5, -0.28)
Costa Rica	14 (13, 16)	1.28 (1.09, 1.5)	25 (21, 30)	1.03 (0.84, 1.26)	-1 (-1.91, -0.08)
Côte d'Ivoire	17 (12, 23)	0.47 (0.31, 0.68)	50 (33, 76)	0.48 (0.29, 0.79)	-2.69 (-3.53, -1.84)
Croatia	191 (170, 216)	7.62 (6.45, 8.92)	76 (63, 92)	3.32 (2.7, 4.02)	-2.06 (-2.46, -1.66)
Cuba	278 (252, 302)	5.38 (4.64, 6.19)	177 (145, 213)	2.86 (2.3, 3.5)	-0.25 (-0.84, 0.35)
Cyprus	7 (5, 9)	1.83 (1.25, 2.55)	14 (10, 18)	1.7 (1.17, 2.36)	-4.4 (-4.89, -3.91)
Czechia	499 (436, 564)	8.65 (7.42, 9.99)	143 (116, 174)	2.14 (1.73, 2.62)	0.05 (-0.24, 0.35)
Democratic People's Republic of Korea	502 (339, 734)	5.09 (3.22, 7.75)	740 (449, 1205)	4.88 (2.77, 8.25)	-0.11 (-0.21, -0.02)
Democratic Republic of the Congo	132 (84, 214)	1.23 (0.73, 2.08)	342 (197, 608)	1.13 (0.6, 2.13)	-0.29 (-0.48, -0.09)
Denmark	187 (173, 201)	6.31 (5.57, 7.1)	65 (57, 74)	2.19 (1.86, 2.57)	-3.38 (-3.94, -2.82)

(Continued)

Table 2 (Continued).

Djibouti	2 (1, 2)	1.2 (0.72, 1.91)	9 (5, 14)	1.46 (0.82, 2.42)	0.59 (0.43, 0.74)
Dominica	1 (0, 1)	2.14 (1.61, 2.82)	1 (1, 1)	2.51 (1.62, 3.64)	0.51 (0.35, 0.68)
Dominican Republic	53 (44, 65)	2.14 (1.65, 2.81)	144 (100, 202)	2.68 (1.78, 3.82)	0.84 (0, 1.69)
Ecuador	61 (56, 67)	1.63 (1.38, 1.92)	107 (81, 139)	1.24 (0.9, 1.68)	-0.86 (-2.38, 0.7)
Egypt	340 (282, 413)	1.59 (1.19, 2.1)	1096 (834, 1420)	2.33 (1.65, 3.19)	1.18 (0.82, 1.54)
El Salvador	30 (26, 36)	1.67 (1.33, 2.06)	49 (37, 64)	1.67 (1.21, 2.23)	-0.08 (-1.07, 0.93)
Equatorial Guinea	2 (1, 4)	1.88 (1.06, 3.33)	10 (6, 16)	2.04 (1.18, 3.36)	0.36 (-0.45, 1.18)
Eritrea	16 (11, 23)	1.49 (0.97, 2.25)	43 (26, 65)	1.66 (0.97, 2.61)	0.33 (0.12, 0.54)
Estonia	57 (51, 65)	7.42 (6.32, 8.69)	15 (12, 18)	2.07 (1.6, 2.5)	-4 (-4.87, -3.12)
Eswatini	6 (4, 10)	2.65 (1.45, 4.63)	18 (10, 29)	4.16 (2.01, 7.08)	1.51 (1.17, 1.86)
Ethiopia	311 (211, 455)	2.14 (1.41, 3.25)	392 (307, 489)	1.07 (0.8, 1.37)	-2.21 (-2.33, -2.1)
Fiji	5 (4, 7)	1.68 (1.11, 2.44)	6 (4, 9)	1.35 (0.85, 2.06)	-0.71 (-0.88, -0.54)
Finland	99 (90, 107)	3.38 (2.91, 3.92)	45 (40, 50)	1.71 (1.44, 2.02)	-1.94 (-2.63, -1.24)
France	1861 (1656, 2087)	6.68 (5.81, 7.68)	1378 (1215, 1556)	4.07 (3.51, 4.66)	-1.53 (-1.65, -1.41)
Gabon	7 (4, 10)	2.44 (1.35, 3.89)	16 (11, 24)	2.23 (1.31, 3.5)	-0.18 (-0.44, 0.07)
Gambia	1 (1, 1)	0.38 (0.24, 0.58)	3 (2, 5)	0.39 (0.24, 0.62)	0.11 (-1.13, 1.36)
Georgia	159 (139, 184)	6.76 (5.83, 7.81)	72 (61, 85)	3.91 (3.29, 4.62)	-1.7 (-3.15, -0.23)
Germany	2434 (2211, 2669)	5.84 (5.08, 6.69)	940 (839, 1054)	2.29 (1.96, 2.65)	-3.04 (-3.42, -2.66)
Ghana	29 (22, 39)	0.6 (0.4, 0.88)	66 (47, 91)	0.48 (0.31, 0.72)	-0.73 (-0.83, -0.62)
Greece	305 (279, 332)	5.9 (5.2, 6.65)	184 (168, 202)	3.08 (2.74, 3.44)	-2.06 (-2.33, -1.8)
Greenland	5 (3, 6)	15.65 (11.47, 20.96)	2 (1, 2)	7.13 (4.85, 9.83)	-2.43 (-2.63, -2.23)
Grenada	1 (0, 1)	2.2 (1.75, 2.7)	1 (1, 1)	1.64 (1.28, 2.1)	-0.87 (-1.91, 0.18)
Guam	3 (2, 3)	4.48 (3.5, 5.65)	5 (4, 5)	5.81 (4.53, 7.4)	0.89 (0.11, 1.68)
Guatemala	46 (43, 49)	1.75 (1.54, 1.96)	75 (63, 88)	1.1 (0.9, 1.33)	-1.46 (-2.56, -0.34)
Guinea	17 (13, 23)	0.89 (0.61, 1.3)	46 (30, 68)	1.12 (0.67, 1.74)	0.74 (0.56, 0.92)
Guinea-Bissau	3 (2, 5)	1.17 (0.71, 1.85)	8 (6, 12)	1.18 (0.72, 1.82)	0.02 (-0.08, 0.12)
Guyana	3 (3, 4)	1.3 (1.02, 1.63)	5 (4, 7)	1.52 (1.04, 2.11)	0.68 (0.15, 1.2)
Haiti	51 (32, 74)	2.39 (1.42, 3.67)	97 (58, 150)	1.72 (0.98, 2.88)	-0.95 (-1.06, -0.83)
Honduras	36 (28, 46)	2.5 (1.8, 3.48)	103 (61, 160)	2.44 (1.33, 4.11)	-0.07 (-0.28, 0.14)
Hungary	698 (612, 790)	12.38 (10.68, 14.31)	240 (194, 293)	3.92 (3.15, 4.8)	-3.95 (-4.46, -3.44)
Iceland	5 (4, 5)	3.98 (3.42, 4.61)	6 (5, 7)	3.53 (2.95, 4.15)	-0.48 (-1.2, 0.25)
India	3634 (3155, 4222)	1.08 (0.93, 1.27)	8736 (7356, 10,136)	1.25 (1.04, 1.48)	0.45 (0.16, 0.74)
Indonesia	1964 (1536, 2366)	2.73 (2.11, 3.33)	4662 (3220, 6477)	2.97 (2.03, 4.09)	0.3 (0.23, 0.36)
Iran (Islamic Republic of)	323 (257, 383)	1.8 (1.44, 2.17)	855 (770, 961)	1.69 (1.5, 1.93)	-0.28 (-0.43, -0.14)
Iraq	124 (86, 172)	2.27 (1.47, 3.4)	367 (250, 520)	1.9 (1.22, 2.86)	-0.61 (-0.79, -0.43)
Ireland	66 (60, 72)	4.05 (3.45, 4.71)	67 (58, 76)	2.33 (1.93, 2.76)	-1.9 (-2.96, -0.83)
Israel	66 (59, 74)	3.33 (2.84, 3.87)	77 (67, 88)	1.65 (1.4, 1.93)	-2.03 (-2.33, -1.73)

(Continued)

Table 2 (Continued).

Italy	1470 (1406, 1529)	5.04 (4.78, 5.3)	670 (631, 707)	1.94 (1.81, 2.06)	-3.25 (-3.6, -2.91)
Jamaica	22 (19, 25)	2.93 (2.34, 3.57)	31 (22, 43)	2.19 (1.48, 3.14)	-0.91 (-2.92, 1.14)
Japan	2026 (1969, 2089)	2.69 (2.6, 2.79)	918 (889, 947)	1.29 (1.24, 1.34)	-2.4 (-2.84, -1.97)
Jordan	24 (18, 30)	2.22 (1.51, 3.06)	94 (69, 129)	1.56 (1.05, 2.33)	-1.06 (-1.43, -0.69)
Kazakhstan	602 (535, 673)	9.8 (8.61, 11.08)	221 (193, 250)	2.28 (1.98, 2.6)	-4.56 (-4.99, -4.12)
Kenya	18 (12, 27)	0.3 (0.2, 0.44)	89 (69, 119)	0.48 (0.36, 0.64)	1.48 (1.32, 1.63)
Kiribati	1 (1, 1)	2.64 (1.77, 3.8)	2 (1, 2)	3.21 (1.94, 5.08)	0.64 (0.54, 0.74)
Kuwait	11 (10, 13)	1.51 (1.21, 1.83)	30 (24, 40)	0.86 (0.64, 1.14)	-1.7 (-2.34, -1.06)
Kyrgyzstan	88 (75, 100)	6.56 (5.44, 7.69)	56 (44, 69)	1.83 (1.44, 2.28)	-4.3 (-4.56, -4.05)
Lao People's Democratic Republic	51 (32, 81)	3.76 (2.22, 6.24)	100 (66, 148)	2.97 (1.86, 4.67)	-0.72 (-0.82, -0.63)
Latvia	91 (80, 105)	6.68 (5.62, 7.9)	25 (20, 31)	2.51 (1.97, 3.11)	-3.16 (-4.58, -1.72)
Lebanon	38 (27, 52)	3.22 (2.18, 4.63)	73 (54, 96)	2.56 (1.77, 3.53)	-0.63 (-0.9, -0.37)
Lesotho	8 (5, 12)	1.54 (0.94, 2.55)	31 (19, 48)	4.5 (2.61, 7.47)	3.57 (3.29, 3.86)
Liberia	5 (3, 7)	0.64 (0.42, 0.99)	15 (8, 26)	0.65 (0.33, 1.17)	0.03 (-0.27, 0.32)
Libya	42 (30, 58)	3.29 (2.12, 4.98)	154 (106, 227)	3.47 (2.18, 5.44)	0.16 (0.02, 0.3)
Lithuania	115 (103, 128)	6.42 (5.42, 7.46)	40 (33, 49)	2.82 (2.19, 3.49)	-2.84 (-4.26, -1.4)
Luxembourg	13 (11, 14)	6.13 (5.38, 6.91)	8 (7, 9)	2.16 (1.84, 2.49)	-3.38 (-4.08, -2.69)
Madagascar	34 (26, 42)	1 (0.7, 1.39)	93 (65, 129)	0.91 (0.57, 1.37)	-0.24 (-0.35, -0.14)
Malawi	9 (6, 11)	0.31 (0.21, 0.45)	26 (18, 36)	0.41 (0.26, 0.64)	0.94 (0.7, 1.19)
Malaysia	134 (108, 167)	2.03 (1.51, 2.71)	391 (306, 499)	2.48 (1.81, 3.34)	0.76 (-0.05, 1.58)
Maldives	1 (1, 2)	1.84 (1.03, 2.78)	3 (2, 4)	0.83 (0.55, 1.2)	-2.65 (-2.83, -2.48)
Mali	15 (12, 19)	0.56 (0.4, 0.77)	40 (28, 56)	0.58 (0.38, 0.86)	0.12 (-0.07, 0.31)
Malta	5 (4, 6)	2.52 (2.05, 3.02)	5 (5, 6)	2.25 (1.81, 2.8)	-0.43 (-1.11, 0.25)
Marshall Islands	1 (0, 1)	3.97 (2.48, 6.26)	1 (1, 2)	5.09 (2.84, 8.04)	0.8 (0.69, 0.91)
Mauritania	5 (4, 7)	0.87 (0.56, 1.3)	11 (7, 16)	0.72 (0.44, 1.15)	-0.66 (-0.85, -0.47)
Mauritius	10 (9, 11)	2.05 (1.79, 2.35)	11 (10, 12)	1.56 (1.32, 1.79)	-1.07 (-2.69, 0.57)
Mexico	570 (553, 587)	1.85 (1.77, 1.92)	710 (628, 802)	1.04 (0.92, 1.18)	-1.88 (-2.57, -1.18)
Micronesia (Federated States of)	2 (1, 2)	4.92 (3.01, 7.8)	3 (2, 4)	5.42 (3.14, 8.52)	0.33 (0.26, 0.4)
Monaco	1 (1, 2)	7.75 (5.55, 10.55)	2 (1, 3)	9.86 (6.38, 14.32)	0.76 (0.58, 0.94)
Mongolia	29 (22, 38)	4.37 (3.07, 6.13)	62 (47, 79)	3.58 (2.52, 4.95)	-0.69 (-1.53, 0.15)
Montenegro	23 (18, 28)	8.32 (6.47, 10.38)	23 (17, 29)	6.68 (4.96, 8.69)	-0.73 (-1.29, -0.17)
Morocco	135 (100, 182)	1.57 (1.03, 2.33)	227 (150, 352)	1.2 (0.73, 1.91)	-0.88 (-0.95, -0.82)
Mozambique	19 (14, 26)	0.45 (0.3, 0.65)	67 (44, 100)	0.72 (0.42, 1.15)	1.53 (1.38, 1.67)
Myanmar	505 (338, 695)	3.48 (2.21, 5.18)	707 (487, 1020)	2.53 (1.63, 3.71)	-1.03 (-1.11, -0.94)
Namibia	4 (3, 5)	0.87 (0.6, 1.22)	10 (6, 15)	0.99 (0.6, 1.52)	0.49 (0.09, 0.89)
Nauru	0 (0, 0)	7.15 (3.46, 11.11)	0 (0, 0)	7.45 (3.52, 11.11)	0.14 (0.07, 0.2)
Nepal	68 (44, 101)	1 (0.61, 1.6)	128 (87, 190)	0.94 (0.58, 1.49)	-0.19 (-0.38, 0.01)

(Continued)

Table 2 (Continued).

Netherlands	421 (391, 453)	5.25 (4.61, 5.96)	232 (208, 258)	2.71 (2.36, 3.11)	-2.04 (-2.14, -1.95)
New Zealand	61 (55, 67)	3.67 (3.25, 4.11)	55 (49, 62)	2.16 (1.88, 2.45)	-1.8 (-2.27, -1.34)
Nicaragua	11 (9, 13)	0.94 (0.71, 1.22)	22 (17, 28)	0.71 (0.49, 0.99)	-1.19 (-1.62, -0.76)
Niger	11 (8, 17)	0.49 (0.31, 0.79)	27 (17, 47)	0.42 (0.24, 0.77)	-0.46 (-0.7, -0.22)
Nigeria	47 (32, 63)	0.16 (0.11, 0.22)	123 (83, 168)	0.16 (0.11, 0.23)	0.01 (-0.1, 0.12)
Niue	0 (0, 0)	3.38 (2.13, 5.16)	0 (0, 0)	3.76 (2.31, 5.91)	0.35 (0.03, 0.66)
North Macedonia	57 (44, 70)	5.98 (4.61, 7.56)	53 (38, 70)	3.95 (2.87, 5.25)	-1.18 (-1.68, -0.67)
Northern Mariana Islands	2 (1, 2)	6.9 (4.2, 10.46)	1 (1, 2)	4.62 (3.19, 6.67)	-1.28 (-1.46, -1.09)
Norway	60 (57, 63)	2.71 (2.54, 2.89)	47 (44, 50)	1.62 (1.49, 1.75)	-1.55 (-1.86, -1.23)
Oman	5 (3, 7)	0.7 (0.42, 1.07)	11 (7, 15)	0.38 (0.25, 0.59)	-2.08 (-2.49, -1.68)
Pakistan	634 (500, 778)	1.76 (1.31, 2.27)	2020 (1509, 2676)	2.1 (1.5, 2.9)	0.58 (0.46, 0.7)
Palau	0 (0, 1)	7.1 (4.75, 10.5)	1 (1, 1)	7.27 (5, 10.34)	0.06 (-0.26, 0.39)
Palestine	16 (11, 23)	2.87 (1.77, 4.35)	46 (37, 58)	2.23 (1.59, 3.08)	-0.86 (-1.16, -0.57)
Panama	17 (16, 19)	1.85 (1.62, 2.09)	22 (17, 28)	1.07 (0.82, 1.35)	-1.66 (-2.62, -0.7)
Papua New Guinea	34 (20, 58)	2.33 (1.26, 4.27)	109 (68, 178)	2.42 (1.32, 4.21)	0.14 (0.05, 0.23)
Paraguay	20 (16, 25)	1.45 (1.07, 1.93)	55 (39, 75)	1.67 (1.13, 2.4)	0.66 (0.31, 1)
Peru	209 (170, 257)	2.57 (1.92, 3.35)	319 (221, 428)	1.74 (1.16, 2.44)	-1.19 (-2.85, 0.5)
Philippines	739 (657, 828)	3.25 (2.84, 3.72)	1430 (1173, 1684)	2.7 (2.21, 3.24)	-0.64 (-0.76, -0.52)
Poland	1528 (1476, 1580)	8.81 (8.43, 9.2)	624 (569, 681)	2.75 (2.49, 3.01)	-3.92 (-4.26, -3.59)
Portugal	190 (169, 212)	3.91 (3.31, 4.62)	146 (129, 165)	2.28 (1.92, 2.68)	-1.79 (-2.67, -0.89)
Puerto Rico	44 (40, 50)	2.58 (2.17, 3.05)	26 (20, 32)	1.54 (1.16, 1.97)	-1.87 (-2.04, -1.71)
Qatar	5 (4, 6)	1.96 (1.31, 2.81)	24 (18, 35)	1.11 (0.73, 1.69)	-1.88 (-3.17, -0.58)
Republic of Korea	872 (725, 1031)	4.18 (3.25, 5.31)	497 (403, 611)	1.57 (1.2, 2.02)	-3.15 (-3.4, -2.91)
Republic of Moldova	128 (115, 142)	6.65 (5.73, 7.65)	53 (45, 62)	2.42 (1.99, 2.91)	-3.36 (-4.11, -2.61)
Romania	821 (697, 959)	7.62 (6.37, 9.03)	522 (419, 637)	4.56 (3.63, 5.58)	-1.61 (-2.03, -1.2)
Russian Federation	4784 (4654, 4903)	7.46 (7.2, 7.7)	2463 (2231, 2676)	2.95 (2.67, 3.21)	-2.95 (-3.39, -2.51)
Rwanda	28 (20, 38)	1.5 (0.96, 2.17)	53 (34, 80)	1.07 (0.62, 1.73)	-1.12 (-1.43, -0.81)
Saint Kitts and Nevis	0 (0, 0)	2.11 (1.8, 2.46)	0 (0, 0)	1.07 (0.79, 1.43)	-2.14 (-2.42, -1.86)
Saint Lucia	1 (1, 1)	2.61 (2.27, 3.01)	2 (2, 2)	1.88 (1.46, 2.36)	-1.15 (-1.63, -0.66)
Saint Vincent and the Grenadines	1 (1, 1)	1.78 (1.52, 2.08)	1 (1, 1)	1.81 (1.48, 2.2)	0.02 (-0.44, 0.48)
Samoa	1 (0, 1)	1.07 (0.69, 1.62)	1 (1, 1)	1.22 (0.73, 1.85)	0.43 (0.34, 0.52)
San Marino	0 (0, 1)	4.09 (2.99, 5.41)	0 (0, 1)	2.11 (1.09, 3.41)	-2.31 (-2.49, -2.13)
Sao Tome and Principe	0 (0, 1)	1.49 (0.98, 2.13)	2 (1, 3)	1.78 (1.02, 3)	0.55 (0.25, 0.84)
Saudi Arabia	51 (35, 69)	0.91 (0.57, 1.35)	243 (168, 344)	0.9 (0.58, 1.37)	0.01 (-0.14, 0.16)
Senegal	19 (14, 26)	0.87 (0.57, 1.3)	48 (34, 70)	0.86 (0.54, 1.37)	0.02 (-0.27, 0.31)
Serbia	401 (313, 517)	8.34 (6.13, 11.22)	261 (197, 336)	5.15 (3.72, 6.86)	-1.44 (-1.83, -1.05)
Seychelles	1 (1, 1)	3.2 (2.31, 4.35)	1 (1, 2)	2.12 (1.48, 2.91)	-1.19 (-1.75, -0.62)

(Continued)

Table 2 (Continued).

Sierra Leone	9 (6, 13)	0.7 (0.45, 1.1)	23 (14, 33)	0.72 (0.41, 1.18)	0.11 (-0.09, 0.32)
Singapore	49 (44, 56)	3.01 (2.57, 3.53)	45 (39, 52)	1.19 (0.97, 1.46)	-2.75 (-3.75, -1.74)
Slovakia	188 (148, 230)	7.53 (5.45, 9.87)	94 (70, 121)	2.78 (1.95, 3.73)	-3.23 (-3.96, -2.49)
Slovenia	60 (53, 68)	5.93 (5.09, 6.83)	23 (18, 29)	1.92 (1.47, 2.45)	-3.64 (-4.74, -2.54)
Solomon Islands	4 (2, 7)	4.27 (2.11, 7.06)	15 (10, 21)	5.15 (3.37, 7.5)	0.63 (0.51, 0.74)
Somalia	24 (14, 44)	0.97 (0.53, 1.9)	61 (32, 129)	0.91 (0.44, 2.03)	-0.18 (-0.28, -0.09)
South Africa	675 (572, 791)	5.1 (4.21, 6.21)	889 (773, 1020)	3.15 (2.65, 3.76)	-1.55 (-2.02, -1.08)
South Sudan	17 (10, 26)	1.03 (0.58, 1.7)	39 (26, 58)	1.14 (0.7, 1.75)	0.37 (-0.04, 0.78)
Spain	1087 (990, 1200)	5.92 (5.1, 6.89)	684 (596, 783)	2.32 (1.97, 2.72)	-3.08 (-3.37, -2.79)
Sri Lanka	123 (98, 158)	1.63 (1.18, 2.26)	154 (97, 219)	1.33 (0.8, 1.99)	-0.6 (-1.23, 0.03)
Sudan	97 (66, 152)	1.49 (0.92, 2.5)	259 (157, 398)	1.52 (0.86, 2.42)	0.06 (0.02, 0.11)
Suriname	3 (3, 4)	2.33 (1.62, 3.15)	7 (5, 9)	2.42 (1.6, 3.46)	0.23 (-1.25, 1.73)
Sweden	131 (120, 143)	2.64 (2.31, 3)	56 (49, 64)	1.09 (0.9, 1.31)	-2.99 (-3.45, -2.53)
Switzerland	150 (135, 167)	3.81 (3.24, 4.41)	81 (71, 90)	1.66 (1.39, 1.97)	-2.79 (-3.42, -2.15)
Syrian Arab Republic	110 (81, 144)	2.93 (2.02, 4.03)	158 (106, 225)	2.08 (1.35, 3.03)	-1.17 (-1.35, -0.99)
Taiwan (Province of China)	346 (315, 380)	3.84 (3.34, 4.41)	513 (441, 581)	3.51 (2.93, 4.13)	-0.36 (-0.64, -0.08)
Tajikistan	60 (45, 76)	4.16 (3.06, 5.54)	71 (45, 112)	1.65 (1.03, 2.6)	-2.98 (-3.17, -2.78)
Thailand	1162 (949, 1435)	4.77 (3.55, 6.38)	1823 (1327, 2442)	4.59 (3.14, 6.47)	-0.11 (-0.53, 0.31)
Timor-Leste	5 (3, 7)	1.74 (1.05, 2.73)	10 (7, 14)	1.86 (1.2, 2.79)	0.24 (-0.21, 0.7)
Togo	8 (6, 11)	0.79 (0.5, 1.2)	30 (17, 47)	0.92 (0.48, 1.54)	0.5 (0.12, 0.87)
Tokelau	0 (0, 0)	2.86 (1.8, 4.48)	0 (0, 0)	3.46 (2.21, 5.25)	0.67 (0.5, 0.85)
Tonga	1 (1, 2)	3.63 (2.52, 5.14)	2 (1, 3)	3.94 (2.42, 6.02)	0.27 (0.07, 0.47)
Trinidad and Tobago	10 (9, 11)	1.97 (1.71, 2.27)	13 (9, 17)	1.69 (1.23, 2.25)	-0.34 (-1.39, 0.72)
Tunisia	63 (49, 81)	2.27 (1.56, 3.16)	162 (106, 231)	2.45 (1.47, 3.72)	0.23 (0.07, 0.4)
Turkey	1982 (1445, 2647)	9.25 (6.25, 13.15)	2008 (1517, 2549)	4.26 (3, 5.74)	-2.59 (-2.96, -2.22)
Turkmenistan	41 (37, 44)	3.7 (3.29, 4.11)	54 (41, 73)	2.18 (1.65, 2.93)	-1.5 (-2.57, -0.43)
Tuvalu	0 (0, 0)	3.47 (2.12, 5.6)	0 (0, 0)	4.12 (2.49, 6.38)	0.57 (0.5, 0.63)
Uganda	35 (25, 46)	0.78 (0.52, 1.13)	130 (86, 185)	1.03 (0.62, 1.55)	0.87 (0.71, 1.03)
Ukraine	2139 (1900, 2403)	8.71 (7.45, 10.17)	836 (551, 1185)	3.27 (2.13, 4.75)	-3.23 (-3.8, -2.65)
United Arab Emirates	22 (14, 32)	2.34 (1.42, 3.59)	91 (62, 140)	0.97 (0.63, 1.53)	-2.74 (-3.7, -1.78)
United Kingdom	1240 (1218, 1266)	4.23 (4.14, 4.33)	675 (657, 695)	1.95 (1.89, 2.02)	-2.52 (-2.92, -2.12)
United Republic of Tanzania	70 (52, 100)	0.99 (0.68, 1.49)	214 (146, 304)	1.05 (0.68, 1.61)	0.16 (0, 0.34)
United States of America	7911 (7710, 8107)	6.25 (6.07, 6.43)	3098 (2996, 3209)	1.91 (1.84, 1.98)	-3.76 (-3.96, -3.56)
United States Virgin Islands	2 (1, 2)	3.07 (2.22, 4.09)	1 (1, 2)	2.87 (1.89, 4.4)	-0.1 (-0.45, 0.24)
Uruguay	113 (98, 127)	7.97 (6.73, 9.3)	74 (61, 88)	4.21 (3.44, 5.09)	-2.21 (-2.49, -1.93)
Uzbekistan	241 (217, 266)	3.95 (3.39, 4.54)	243 (202, 292)	1.41 (1.12, 1.75)	-3.19 (-4.98, -1.38)
Vanuatu	1 (1, 3)	2.72 (1.34, 5.27)	4 (2, 7)	3.04 (1.69, 5.36)	0.34 (0.21, 0.46)

(Continued)

Table 2 (Continued).

Venezuela (Bolivarian Republic of)	236 (218, 254)	3.44 (3.03, 3.87)	337 (244, 453)	2.33 (1.66, 3.17)	-1.25 (-1.67, -0.82)
Viet Nam	549 (397, 734)	2.84 (1.89, 4.04)	1863 (1335, 2634)	3.38 (2.24, 5.09)	0.58 (0.5, 0.66)
Yemen	63 (34, 113)	1.73 (0.91, 3.17)	196 (108, 336)	1.58 (0.83, 2.79)	-0.34 (-0.54, -0.14)
Zambia	26 (21, 33)	1.21 (0.85, 1.7)	123 (77, 251)	1.86 (1.06, 3.96)	1.4 (1.24, 1.56)
Zimbabwe	41 (32, 52)	1.5 (1.05, 2.03)	150 (100, 219)	2.58 (1.64, 3.92)	1.84 (1.32, 2.36)

Abbreviations: ASIR, Age-Standardized Incidence Rate; ASMR, Age-Standardized Mortality Rate; AAPC, average annual percent change.

95% CI: -4.66 to -3.42), and Canada (-3.55%; 95% CI: -3.80 to -3.29). In contrast, Lesotho (+3.58%; 95% CI: 3.30–3.85), Zimbabwe (+1.84%; 95% CI: 1.30–2.38), and Kenya (+1.51%; 95% CI: 1.36–1.66) showed significant increases (Table 2 and Figure 2C). These patterns reflect strong associations between EOLC burden and the effectiveness of national tobacco control, environmental policy, and screening initiatives.

Belize recorded the largest increases in both prevalence (+417%) and incidence (+416%) (Figure 5A and B), while Estonia showed the steepest declines (-66% and -71%, respectively). The highest rise in deaths was observed in Djibouti (+449%), while Estonia had the greatest reduction (-74%) (Figure 5C). Djibouti also experienced the largest increase in DALYs (+445%), whereas Estonia again saw the most substantial decrease (-74%) (Figure 5D).

Age- and Sex-Specific Trends

Epidemiological patterns of EOLC demonstrated marked variation by sex, age, and region. In 2021, an estimated 145,007 cases were reported in males (95% UI: 124,860–167,203), reflecting an 18.0% increase since 1990. Among females, cases rose to 96,414 (95% UI: 85,314–109,215), indicating a steeper upward trajectory. Between 1990 and 2021, the age-standardized prevalence rate declined in males (from 8.94 to 7.25 per 100,000) but increased in females (from 4.13 to 4.95).

Age-stratified trends showed more pronounced declines among males, particularly in the 35–39 (11.49 to 7.55) and 45–49 (46.31 to 30.25) age groups. In contrast, female prevalence slightly declined in the 40–44 group (9.74 to 9.20) but rose in the 45–49 group (17.75 to 18.52). Among adolescents (15–19 years), prevalence decreased in both sexes—males: 0.51 to 0.29; females: 0.28 to 0.23 per 100,000 (Figure 6).

Increases were most evident among young and middle-aged women in high-SDI regions, whereas elevated prevalence persisted among young men in low- and middle-SDI regions. These disparities likely reflect unequal exposure to risk factors, inconsistent screening coverage, and gaps in healthcare access.

Despite higher absolute mortality among males in 2021 (64,278 vs 34,856 in females; 1.8-fold difference), the burden has shifted. From 1990 to 2021, female deaths rose by 33.4% and incidence by 49.3%, while male deaths remained stable (-0.2%) and incidence increased only slightly (+5.8%). These trends highlight a rapidly growing impact of EOLC among women (Figure 6).

Risk Factor Attribution

This study evaluated premature lung cancer deaths and DALYs attributable to six major risk factors—tobacco use, air pollution, occupational exposures, dietary risks, residential radon, and metabolic factors—using GBD 2021 data stratified by region.

Globally, tobacco was the leading contributor to EOLC burden in individuals aged 15–49, responsible for 47.13% of deaths and 45.69% of DALYs. Air pollution ranked second (22.16% of deaths; 22.02% of DALYs), followed by occupational risks (9.28% and 9.01%, respectively).

Risk factor distributions varied considerably by region. Tobacco was the dominant risk in East Asia, Central Asia, and Eastern Europe, accounting for up to 65.54% of deaths and 64.57% of DALYs in Eastern Europe. In contrast, air pollution was the primary driver in South and Southeast Asia, contributing 33.70% of deaths and 33.25% of DALYs. Occupational risks were also prominent in East, Southeast, and Central Asia, accounting for 8.89–10.44% of deaths and

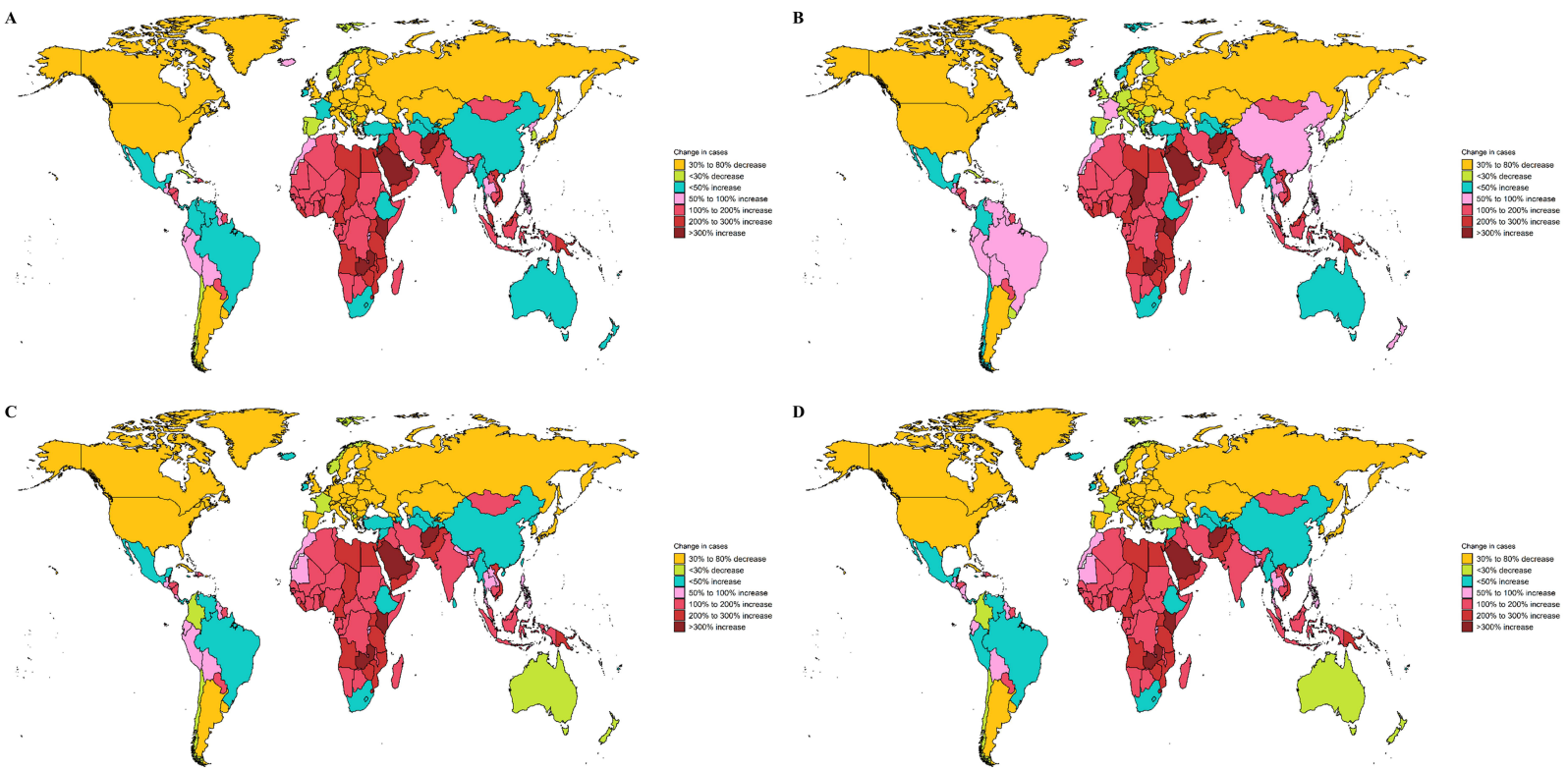


Figure 5 Changes in early-onset lung cancer cases across 204 countries and territories. (A) Incidence; (B) Prevalence; (C) Mortality; (D) DALYs.

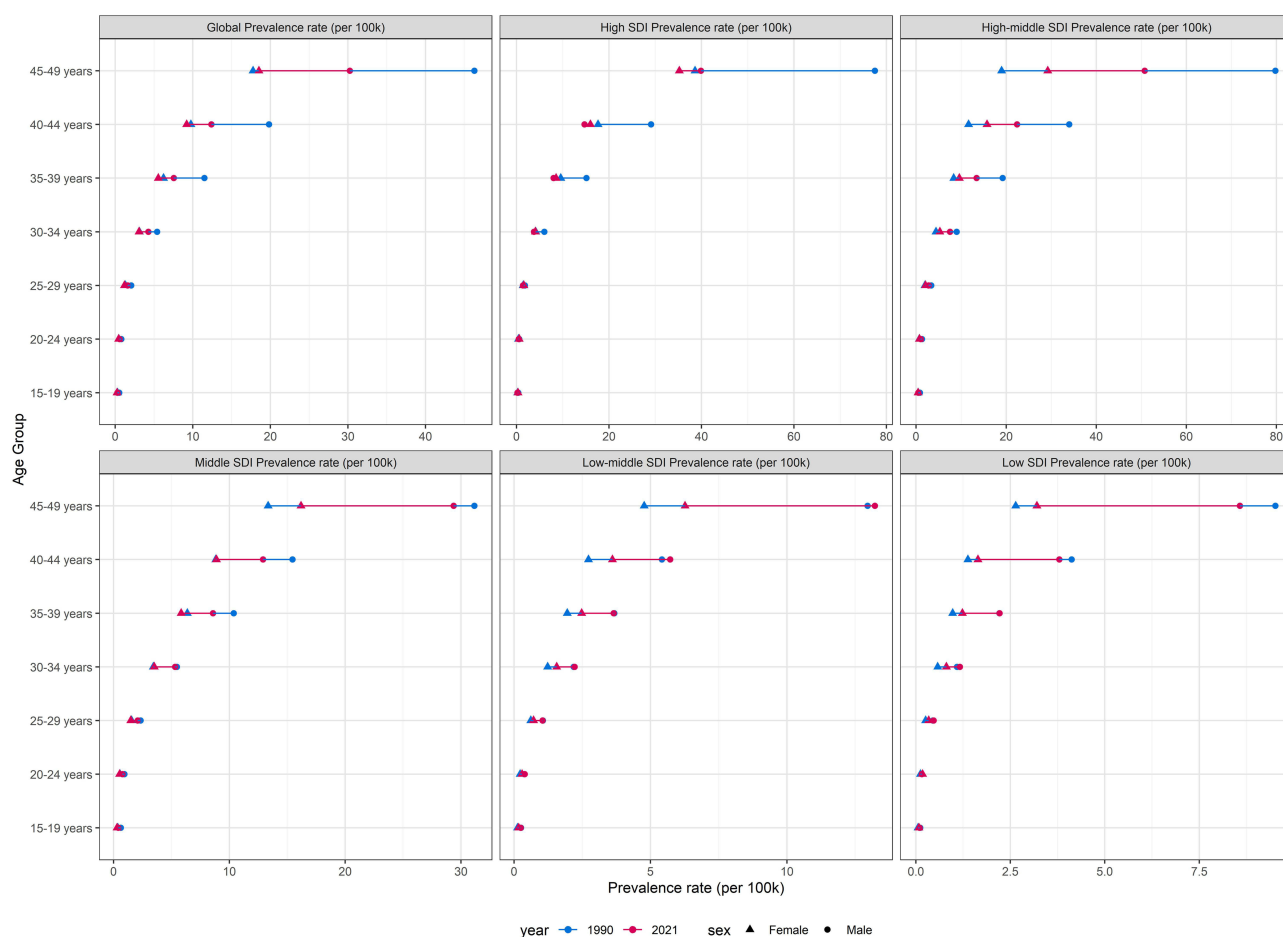


Figure 6 Prevalence of early-onset lung cancer by sex, age group, and SDI, in 1990 and 2021.

8.60–10.09% of DALYs (Figure 7). While dietary risks and radon exposure contributed smaller shares, their effects were still notable.

The strong concordance between mortality and DALY estimates highlights that these risk factors not only lead to premature death but also substantially impair quality of life—underscoring the urgency of implementing region-specific, evidence-based prevention strategies.

Trends in China

An analysis of disease trends in China, India, and the United States—the world’s three most populous nations—revealed distinct patterns. In China, the ASMR declined from 6.30 (95% uncertainty interval [UI]: 5.31–7.35) in 1990 to 5.03 (95% UI: 3.92–6.23) in 2021, with an AAPC of -0.74% (95% confidence interval [CI]: -0.90 to -0.58). The ASIR also fell, from 6.95 per 100,000 (95% UI: 5.85–8.11) to 6.51 per 100,000 (95% UI: 5.10–8.05), yielding an AAPC of -0.21% (95% CI: -0.37 to -0.05). These figures indicate a gradual yet sustained decline in both mortality and incidence. In India, both rates increased. ASMR rose from 1.08 (95% UI: 0.93–1.27) to 1.25 (95% UI: 1.04–1.48), with an AAPC of 0.45% (95% CI: 0.16 to 0.74), while ASIR climbed from 1.17 per 100,000 (95% UI: 1.00–1.36) to 1.38 per 100,000 (95% UI: 1.15–1.63), with an AAPC of 0.53% (95% CI: 0.24 to 0.82). India was the only country among the three to exhibit a consistent upward trend. In contrast, the United States demonstrated the most substantial progress. ASMR fell sharply from 6.25 (95% UI: 6.07–6.43) in 1990 to 1.91 (95% UI: 1.84–1.98) in 2021, with an AAPC of -3.76% (95% CI: -3.96 to -3.56). ASIR followed a similar trajectory, decreasing from 8.18 per 100,000 (95% UI: 7.93–8.43) to 2.76 per 100,000 (95% UI: 2.66–2.88), corresponding to an AAPC of -3.46% (95% CI: -3.69 to -3.23) (Table 2).

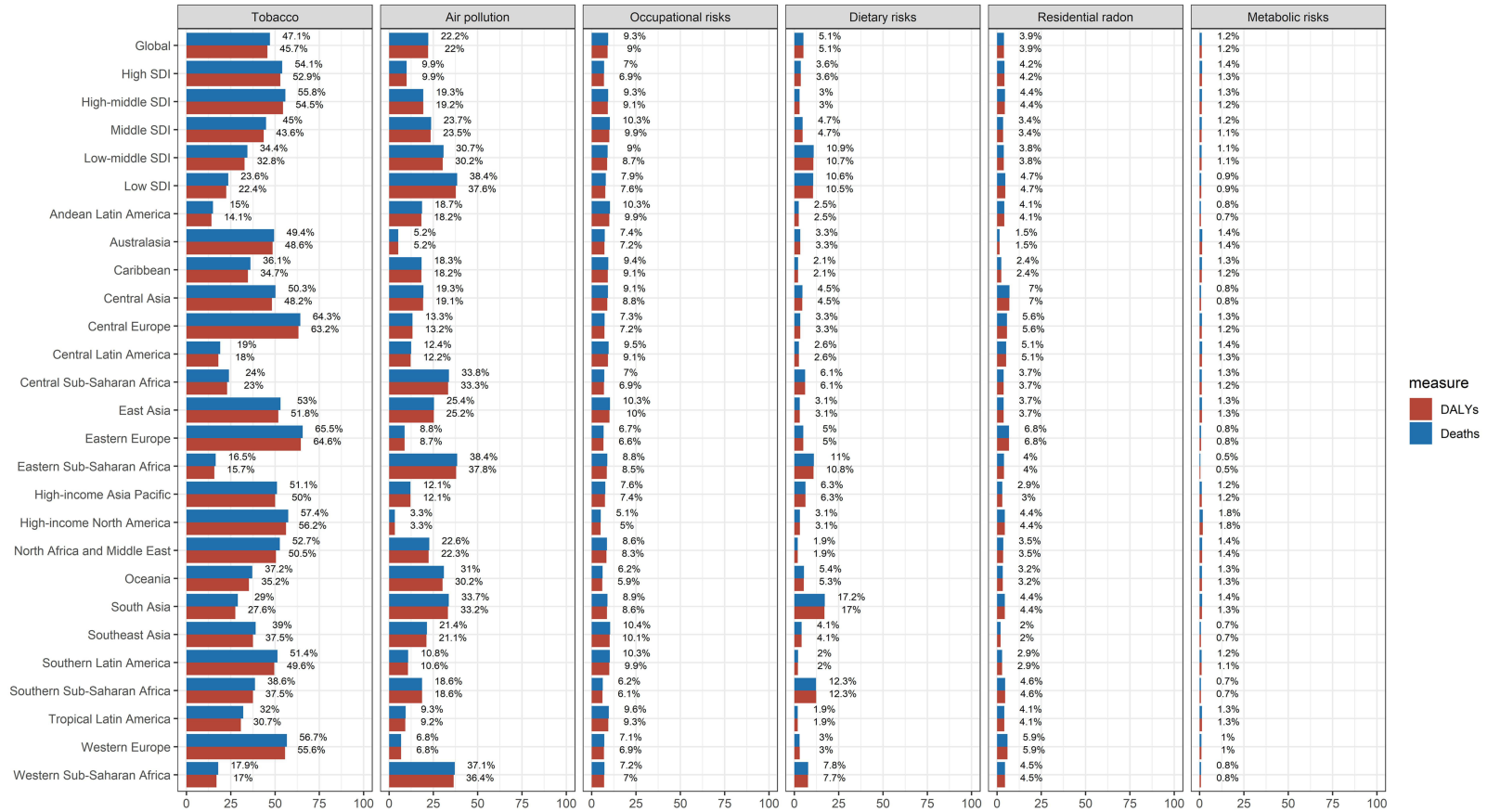


Figure 7 Distribution of risk factors contributing to early-onset lung cancer at global and regional levels.

Despite overall national stability, pronounced sex-specific disparities emerged. Joinpoint regression revealed a distinct and troubling trend in females: from 2015 to 2021, incidence rose sharply (APC = 2.0%, 95% CI: 1.76–2.23), and mortality reversed from decline to increase (APC = 1.12%, 95% CI: 0.92–1.32). Female incidence climbed from 3.83 to 6.18 per 100,000 between 1990 and 2021, highlighting a growing disease burden. By contrast, male incidence remained stable (APC = 0.16%), and mortality continued to decline (APC = –0.49%) (Table 3). These patterns signal a rapidly escalating EOLC risk among Chinese women, warranting urgent public health action.

Attribution analysis of lung cancer in Chinese women aged 15–49 revealed shifting patterns in key modifiable risk factors. Smoking-related attributable fractions (AFs) for deaths and DALYs peaked around 2009 (9.04% and 8.71%, respectively) before declining to 7.87% and 7.56% by 2021. Particulate matter pollution remained the dominant contributor, though its AF declined substantially—from 39.44% to 25.75% for deaths and from 38.70% to 25.58% for DALYs. Secondhand smoke remained a consistent risk, responsible for roughly 13–14% of deaths and 13% of DALYs. In contrast, occupational carcinogen exposure rose steadily, with AFs increasing from 7.37% (deaths) and 7.12% (DALYs) in 1990 to 10.47% and 10.17% in 2021. The burden attributable to low fruit intake fell markedly (deaths: 8.64% to 2.93%; DALYs: 8.68% to 2.94%), while residential radon exposure remained relatively unchanged (3.7–3.8%) (Figure 8). These findings underscore the need to intensify efforts targeting occupational hazards and secondhand smoke, alongside sustained tobacco control and air quality improvement, to reduce lung cancer burden in this population.

Discussion

Drawing on data from the GBD Study 2021, our analysis highlights a dual shift in EOLC: geographically toward low- and middle-SDI regions, and demographically toward increased incidence among women.¹⁷ Within this global pattern, China stands out due to a troubling reversal in EOLC trends among young women—an alarming development given its already highest national lung cancer burden worldwide.¹⁸ While EOLC rates have declined among the broader Chinese population and men, young women have experienced a sharp rise since 2015. Joinpoint regression analysis revealed an annual increase of 2.0% in incidence and a shift in mortality from decline to growth (APC = 1.12%) between 2015 and 2021. This reversal marks a rapidly intensifying burden, exceeding global trends observed among females.⁹

The drivers of this rising burden in young Chinese women are multifactorial. Risk attribution analysis identifies several key contributors, against a backdrop of declining active smoking prevalence in China. Firstly, secondhand smoke (SHS) exposure remains a major risk, accounting for approximately 13–14% of EOLC mortality in young women, highlighting persistent and widespread passive exposure.^{19–21} Secondly, ambient particulate matter pollution continues to be the leading environmental cause of EOLC mortality in this group,^{22–24} our findings align with prior research conducted in China regarding the contribution of air pollution to the lung cancer burden.^{4,25,26} Thirdly, and most notably, occupational exposure to carcinogens has shown the most pronounced increase in attributable burden, rising from 7.37% in 1990 to 10.47% in 2021, suggesting changing occupational environments are a critical driver.^{27,28} Additionally, household exposures such as cooking oil fumes—prevalent in Chinese cooking practices and containing over 200 harmful gases—have been associated with elevated lung cancer risk in nonsmoking women through meta-analyses showing dose-response relationships with exposure duration.²⁹

Notably, the traditional profile of the active (male) smoker does not dominate EOLC risk in young Chinese women. While the prevalence of active smoking among Chinese women is low and continues to decline, the emerging use of electronic cigarettes (e-cigarettes or vaping) among youth and young adults globally introduces a new potential risk. The aerosols from e-cigarettes contain fine particulate matter and other toxicants, and their long-term health effects, particularly on lung cancer risk, are not yet fully understood. Although current use among Chinese adult females remains very low (~0.1%),³⁰ global trends warrant vigilance and further study to assess its future impact.

Collectively, these findings indicate that the traditional lung cancer prevention model—largely focused on male smokers—no longer adequately reflects the evolving risk profile among young Chinese women.³¹ Emerging data suggest the involvement of sex-specific biological factors, including potential interactions between hormonal influences and environmental carcinogens.^{32–34} Estrogen receptors are present in both normal and malignant lung tissue, and estrogen has been shown to stimulate gene transcription and activate growth factor signaling, particularly via the epidermal growth factor receptor (EGFR) pathway.³⁵ Nonetheless, the underlying mechanisms remain poorly understood and warrant

Table 3 Sex-Specific Annual Percentage Changes in Early-Onset Lung Cancer Incidence and Mortality, Based on Joinpoint Analysis, 1990–2021

Sex	Period 1	APC	Period 2	APC	Period 3	APC	Period 4	APC	Period 5	APC	Period 6	APC
Incidence												
Both	1990–2004	0.12 (0.06, 0.18)	2004–2007	-2.32 (-2.69, -1.68)	2007–2010	0.96 (0.32, 1.38)	2010–2015	-1.65 (-2.12, -1.43)	2015–2021	0.73 (0.51, 1.03)		
Male	1990–2004	0.18 (0.11, 0.26)	2004–2007	-2.53 (-2.94, -1.78)	2007–2010	1.18 (0.48, 1.66)	2010–2016	-1.35 (-1.9, -1.12)	2016–2021	0.16 (-0.21, 0.78)		
Female	1990–1996	0.46 (0.22, 1.04)	1996–2004	-0.1 (-0.4, 0.08)	2004–2007	-1.59 (-1.97, -0.9)	2007–2010	0.56 (-0.25, 0.98)	2010–2015	-1.87 (-2.2, -1.58)	2015–2021	2 (1.76, 2.23)
Death												
Both	1990–2004	-0.18 (-0.24, -0.11)	2004–2007	-3.47 (-3.83, -2.99)	2007–2010	0.4 (-0.24, 0.81)	2010–2015	-2.29 (-2.74, -2.05)	2015–2021	0.09 (-0.14, 0.36)		
Male	1990–2004	-0.06 (-0.13, 0.02)	2004–2007	-3.44 (-3.83, -2.65)	2007–2010	0.88 (0.18, 1.36)	2010–2015	-2 (-2.61, -1.7)	2015–2021	-0.49 (-0.76, -0.08)		
Female	1990–1999	-0.01 (-0.14, 0.21)	1999–2004	-0.85 (-1.25, -0.45)	2004–2007	-2.93 (-3.34, -2.36)	2007–2010	-0.42 (-1.05, -0.01)	2010–2015	-2.86 (-3.18, -2.65)	2015–2021	1.12 (0.92, 1.32)

Abbreviation: APC, Age-Period-Cohort Model.

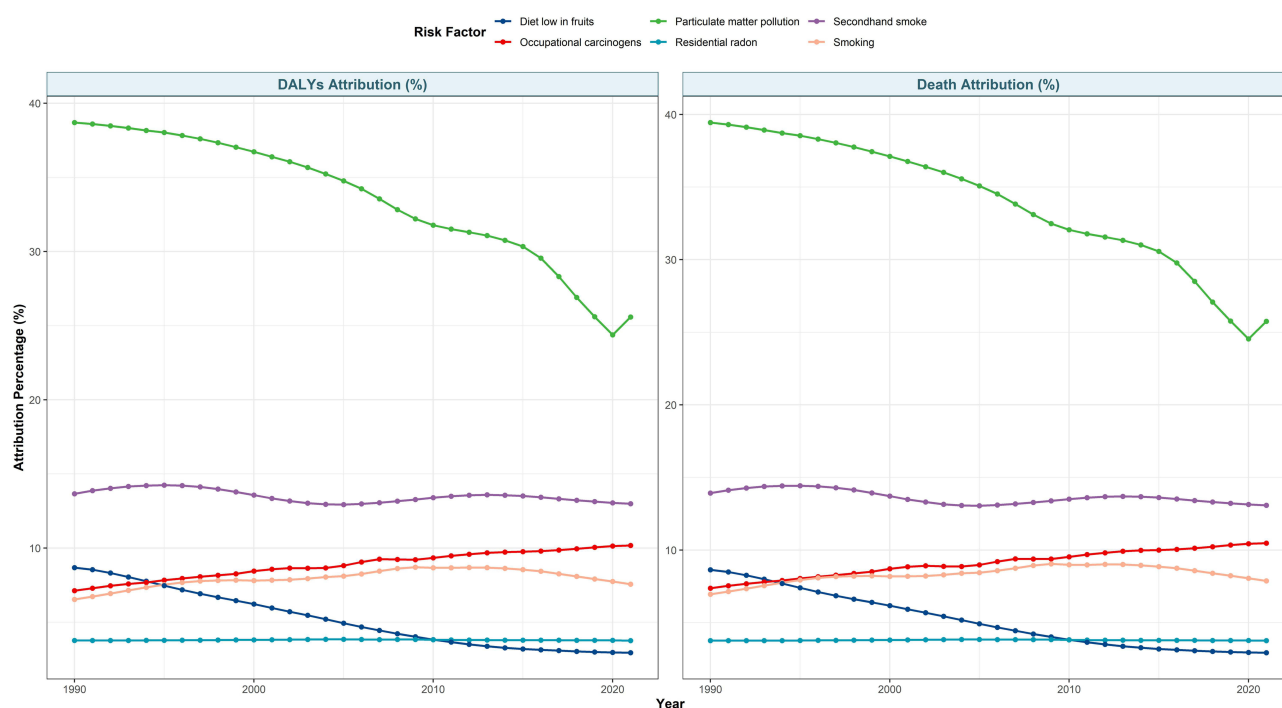


Figure 8 Risk factor–attributable mortality and DALYs from early-onset lung cancer among Chinese women.

further investigation. A family history of lung cancer is a well-established risk factor, although its differential impact by sex remains uncertain.^{36,37} A study in Taiwan reported that among non-smokers, women were more likely than men to have HPV-positive lung cancer. Furthermore, HPV-positive women had a higher likelihood of developing adenocarcinoma compared to their HPV-negative counterparts.^{38,39}

Our findings underscore an urgent need for gender-sensitive public health interventions in China. The rising incidence of EOLC among young women calls for immediate, targeted measures. Key priorities include: (1) Strict enforcement of smoke-free policies in public and workplace settings to minimize secondhand smoke exposure; (2) Enhanced occupational safety standards for women in high-risk industries (eg, those involving diesel exhaust, asbestos, or heavy metals); (3) Public and professional education campaigns emphasizing lung cancer risks in non-smoking women; (4) Feasibility assessments for risk-based early screening programs tailored to high-risk populations or regions.

This study is subject to limitations inherent in its macro-epidemiological design. Estimates derived from the GBD framework rely on modeling and national surveillance data, which may be affected by under-diagnosis and under-reporting—particularly in resource-limited areas. Critically, the GBD 2021 risk factor framework does not provide separate estimates for electronic cigarette use, a potential emerging exposure whose prevalence, while currently low among Chinese women, requires monitoring. Importantly, the GBD data aggregate lung cancer without histologic subtyping. Additionally, while population-level associations offer valuable insights, individual-level exposure-response dynamics and mechanistic pathways require further investigation through focused epidemiological and translational research.

Conclusion

In conclusion, our analysis identifies young Chinese women as bearing a distinct and growing burden of early-onset lung cancer. This trend not only represents an emerging public health crisis within China but also contrasts with broader global patterns. The magnitude and unique drivers of this burden necessitate an urgent paradigm shift in prevention and policy. Moving beyond traditional frameworks centered on male smoking, comprehensive strategies must now be developed to address the specific environmental, occupational, and biological risk profiles of this vulnerable population, particularly occupational and environmental exposures, alongside emerging risks such as e-cigarette use among youth globally.

Abbreviations

EOLC, early-onset lung cancer; GBD, the Global Burden of Disease; DALYs, disability-adjusted life years; ASIR, Age-standardized incidence rates; ASMR, Age-standardized mortality rates; ASDR, Age-standardized DALY rate; SDI, Socio-demographic Index; IHME, the Institute for Health Metrics and Evaluation; UIs, uncertainty intervals; APC, annual percent change; AAPC, average annual percent change; SHS, Secondhand smoke; EGFR, the epidermal growth factor receptor.

Data Sharing Statement

All original data is available at <https://vizhub.healthdata.org/gbd-results/>. All the information presented is referred in the manuscript, for additional information, inquiries can be directed to the corresponding author.

Ethics Declarations

This study utilized publicly available, de-identified data from the Global Burden of Disease Study 2021. According to the Measures for Ethical Review of Life Science and Medical Research Involving Human Subjects (China, February 18, 2023), Articles 32.1 and 32.2, research based on publicly available databases without individual identifiers is exempt from institutional ethics review. Therefore, no separate ethics approval was required for this analysis.

Acknowledgments

The authors thank all contributors to the Global Burden of Disease Study 2021 for their invaluable support.

Funding

This work was supported by: Tai Shan Young Scholar Program, Shandong Province (No. tsqn202312383), National Natural Science Foundation of China (Nos. 82472959, 82273069), Shandong Medical and Health Science and Technology Project (No. 202404020093), Clinical Research Fund, Affiliated Hospital of Jining Medical University (No. LCYJ-016) and Major R&D Programs of Jining City (Nos. 2024YXNS067, 2023YXNS104).

Disclosure

The authors declare no competing interests. We clarify that there are no funding sources or affiliations that may influence the design, analysis, or interpretation of the research.

References

1. Bray F, Laversanne M, Sung H, et al. Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin.* 2024;74(3):229–263. doi:10.3322/caac.21834
2. Ugai T, Sasamoto N, Lee H-Y, et al. Is early-onset cancer an emerging global epidemic? Current evidence and future implications. *Nat Rev Clin Oncol.* 2022;19(10):656–673. doi:10.1038/s41571-022-00672-8
3. Timofeeva M, Kropp S, Sauter W, et al. Genetic polymorphisms of MPO, GSTT1, GSTM1, GSTP1, EPHX1 and NQO1 as risk factors of early-onset lung cancer. *Int J Cancer.* 2010;127(7):1547–1561. doi:10.1002/ijc.25175
4. Teng Y, Xia C, Cao M, et al. Lung cancer burden and trends from 2000 to 2018 in China: comparison between China and the United States. *Chin J Cancer Res.* 2023;35(6):618–626. doi:10.21147/j.issn.1000-9604.2023.06.06
5. Wang F, Guo Z, Tang W, et al. Lipidomic signatures as predictive biomarkers for early-onset lung cancer: identification and development of a risk prediction model. *J Adv Res.* 2025.
6. Liu B, Quan X, Xu C, et al. Lung cancer in young adults aged 35 years or younger: a full-scale analysis and review. *J Cancer.* 2019;10(15):3553–3559. doi:10.7150/jca.27490
7. Liu C, Shi J, Wang H, et al. Population-level economic burden of lung cancer in China: provisional prevalence-based estimations, 2017–2030. *Chin J Cancer Res.* 2021;33(1):79–92. doi:10.21147/j.issn.1000-9604.2021.01.09
8. Murray CJL. Findings from the Global Burden of Disease Study 2021. *Lancet.* 2024;403(10440):2259–2262. doi:10.1016/S0140-6736(24)00769-4
9. Leiter A, Veluswamy RR, Wisnivesky JP. The global burden of lung cancer: current status and future trends. *Nat Rev Clin Oncol.* 2023;20(9):624–639. doi:10.1038/s41571-023-00798-3
10. Brauer M, Roth GA, Aravkin AY, et al. Global burden and strength of evidence for 88 risk factors in 204 countries and 811 subnational locations, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021. *Lancet.* 2024;403(10440):2162–2203.
11. Ebrahimi H, Aryan Z, Moghaddam SS, et al. Global, regional, and national burden of respiratory tract cancers and associated risk factors from 1990 to 2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet Respir Med.* 2021;9(9):1030–1049. doi:10.1016/S2213-2600(21)00164-8

12. Wu Z, Xia F, Lin R. Global burden of cancer and associated risk factors in 204 countries and territories, 1980–2021: a systematic analysis for the GBD 2021. *J Hematol Oncol.* 2024;17(1):119. doi:10.1186/s13045-024-01640-8
13. Feigin VL, Stark BA, Johnson CO, et al. Global, regional, and national burden of stroke and its risk factors, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet Neurol.* 2021;20(10):795–820. doi:10.1016/S1474-4422(21)00252-0
14. Ferrari AJ, Santomauro DF, Aali A, et al. Global incidence, prevalence, years lived with disability (YLDs), disability-adjusted life-years (DALYs), and healthy life expectancy (HALE) for 371 diseases and injuries in 204 countries and territories and 811 subnational locations, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021. *Lancet.* 2024;403(10440):2133–2161.
15. Ma X, Jiang L, Han B, et al. Trends in liver cancer burden in China and G20: a comparative analysis using GBD 2021. *Front Oncol.* 2025;15:1642502. doi:10.3389/fonc.2025.1642502
16. Knoll M, Furkel J, Debus J, Abdollahi A, Karch A, Stock C. An R package for an integrated evaluation of statistical approaches to cancer incidence projection. *BMC Med Res Methodol.* 2020;20(1). doi:10.1186/s12874-020-01133-5
17. Ragavan M, Patel MI. The evolving landscape of sex-based differences in lung cancer: a distinct disease in women. *Eur Respir Rev.* 2022;31(163):210100. doi:10.1183/16000617.0100-2021
18. Shi J, Shiraishi K, Choi J, et al. Genome-wide association study of lung adenocarcinoma in East Asia and comparison with a European population. *Nat Commun.* 2023;14(1):3043. doi:10.1038/s41467-023-38196-z
19. Jin Y, Xu Y, Xu M, Xue S. Increased risk of cancer among relatives of patients with lung cancer in China. *BMC Cancer.* 2005;5(1):146. doi:10.1186/1471-2407-5-146
20. Ang L, Chan CPY, Yau W-P, Seow WJ. Association between family history of lung cancer and lung cancer risk: a systematic review and meta-analysis. *Lung Cancer.* 2020;148:129–137. doi:10.1016/j.lungcan.2020.08.012
21. Öberg M, Jaakkola MS, Woodward A, Peruga A, Prüss-Ustün A. Worldwide burden of disease from exposure to second-hand smoke: a retrospective analysis of data from 192 countries. *Lancet.* 2011;377(9760):139–146. doi:10.1016/S0140-6736(10)61388-8
22. Guo H, Chang Z, Wu J, Li W. Air pollution and lung cancer incidence in China: who are faced with a greater effect? *Environ Int.* 2019;132:105077. doi:10.1016/j.envint.2019.105077
23. Hosgood HD, Song M, Hsiung CA, et al. Interactions between household air pollution and GWAS-identified lung cancer susceptibility markers in the Female Lung Cancer Consortium in Asia (FLCCA). *Hum Genet.* 2015;134(3):333–341. doi:10.1007/s00439-014-1528-z
24. Li D, Shi J, Liang D, Ren M, He Y. Lung cancer risk and exposure to air pollution: a multicenter North China case-control study involving 14604 subjects. *BMC Pulm Med.* 2023;23(1). doi:10.1186/s12890-023-02480-x
25. Yin P, Brauer M, Cohen AJ, Wang H, Murray CJL. The effect of air pollution on deaths, disease burden, and life expectancy across China and its provinces, 1990–2017: an analysis for the Global Burden of Disease Study 2017. *Lancet Planet Health.* 2020;4(9):e386–e398. doi:10.1016/S2542-5196(20)30161-3
26. Yue H, He C, Huang Q, Yin D, Bryan BA. Stronger policy required to substantially reduce deaths from PM2.5 pollution in China. *Nat Commun.* 2020;11(1):1462. doi:10.1038/s41467-020-15319-4
27. GBD 2016 Occupational Carcinogens Collaborators. Global and regional burden of cancer in 2016 arising from occupational exposure to selected carcinogens: a systematic analysis for the Global Burden of Disease Study 2016. *Occup Environ Med.* 2020;77(3):151–159. doi:10.1136/oemed-2019-106012
28. Kim J, Peters CE, Arrandale VH, et al. Burden of lung cancer attributable to occupational diesel engine exhaust exposure in Canada. *Occup Environ Med.* 2018;75(9):617–622. doi:10.1136/oemed-2017-104950
29. Huang J, Yue N, Shi N, et al. Influencing factors of lung cancer in nonsmoking women: systematic review and meta-analysis. *J Public Health.* 2021;44(2):259–268. doi:10.1093/pubmed/fdaa254
30. Chinese Center for Disease Control and Prevention. Key findings and results of the 2024 China Adult Tobacco Survey. 2025. Available from: https://www.chinacdc.cn/jksj/jksj04/202506/t20250616_307668.html. Accessed December 31, 2025.
31. Hellyer JA, Patel MI. Sex disparities in lung cancer incidence: validation of a long-observed trend. *Transl Lung Cancer Res.* 2019;8(4):543–545. doi:10.21037/tlcr.2019.04.06
32. Yin X, Kishida R, Abe SK, et al. Association between reproductive factors with lung cancer incidence and mortality: a pooled analysis of over 308,000 females in the Asia cohort consortium. *Int J Cancer.* 2024;154(12):2090–2105. doi:10.1002/ijc.34866
33. Rosell R, Moran T, Queralt C, et al. Screening for epidermal growth factor receptor mutations in lung cancer. *N Engl J Med.* 2009;361(10):958–967. doi:10.1056/NEJMoa0904554
34. Stabile LP, Davis ALG, Gubish CT, et al. Human non-small cell lung tumors and cells derived from normal lung express both estrogen receptor alpha and beta and show biological responses to estrogen. *Cancer Res.* 2002;62(7):2141–2150.
35. Schwartz AG, Wenzlaff AS, Prysak GM, et al. Reproductive factors, hormone use, estrogen receptor expression and risk of non-small-cell lung cancer in women. *J Clin Oncol.* 2007;25(36):5785–5792. doi:10.1200/JCO.2007.13.3975
36. Isla D, Majem M, Viñolas N, et al. A consensus statement on the gender perspective in lung cancer. *Clin Transl Oncol.* 2016;19(5):527–535. doi:10.1007/s12094-016-1578-x
37. North CM, Christiani DC. Women and lung cancer: what is new? *Semin Thorac Cardiovasc Surg.* 2013;25(2):87–94. doi:10.1053/j.semtcvs.2013.05.002
38. Cheng YW, Chiou HL, Sheu GT, et al. The association of human papillomavirus 16/18 infection with lung cancer among nonsmoking Taiwanese women. *Cancer Res.* 2001;61(7):2799–2803.
39. Bae J-M, Kim EH. Human papillomavirus infection and risk of lung cancer in never-smokers and women: an ‘adaptive’ meta-analysis. *Epidemiol Health.* 2015;37:e2015052. doi:10.4178/epih/e2015052

International Journal of Women's Health

Publish your work in this journal

The International Journal of Women's Health is an international, peer-reviewed open-access journal publishing original research, reports, editorials, reviews and commentaries on all aspects of women's healthcare including gynecology, obstetrics, and breast cancer. The manuscript management system is completely online and includes a very quick and fair peer-review system, which is all easy to use. Visit <http://www.dovepress.com/testimonials.php> to read real quotes from published authors.

Submit your manuscript here: <https://www.dovepress.com/international-journal-of-womens-health-journal>

Dovepress

Taylor & Francis Group