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Global, regional, and national burden of chronic respiratory diseases and impact of the COVID-19 pandemic, 1990–2023: a Global Burden of Disease study

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Chronic respiratory diseases, including chronic obstructive pulmonary disease (COPD), asthma, pneumoconiosis, interstitial lung disease (ILD) and pulmonary sarcoidosis, are major global causes of mortality and morbidity. Although the COVID-19 pandemic has influenced acute respiratory health, its impact on chronic respiratory conditions remains unclear. We estimated the global, regional and national burden of chronic respiratory diseases from 1990 to 2023, including risk factors, and evaluated how these burdens have shifted during the COVID-19 pandemic using the Global Burden of Disease Study 2023. In 2023, chronic respiratory diseases accounted for 569.2 million (95% uncertainty interval (UI), 508.8–639.8) cases and 4.2 million (3.6–5.1) deaths. The age-standardized death rate declined by 25.7% globally from 1990 to 2023 despite an increase in ILD and pulmonary sarcoidosis. Mortality declined in younger males, especially for asthma, whereas older adults experienced a rise in ILD and pulmonary sarcoidosis. Smoking was the primary risk factor for COPD, whereas high body mass index and silica exposure were key risk factors for asthma and pneumoconiosis. During the pandemic, the incidence of chronic respiratory diseases increased modestly, but the decline in mortality rates became more pronounced, highlighting the need for sustained global attention and action to address their long-term burden.

The lungs are continually exposed to numerous irritants, including pollutants, tobacco smoke and infections, throughout the lifespan[1]. Despite substantial efforts to understand the pathophysiology of chronic respiratory diseases and to reduce their burden over the past decades[2,3], chronic respiratory diseases—including chronic obstructive pulmonary disease (COPD), asthma, pneumoconiosis, interstitial lung disease (ILD) and pulmonary sarcoidosis—remain a leading cause of mortality among non-communicable diseases (NCDs)[4].

Global initiatives aim to enhance the prevention, diagnosis, and management of chronic respiratory diseases. For instance, the World Health Organization's Global Alliance against Chronic Respiratory Diseases (GARD)[5] focuses on reducing exposure to risk factors while strengthening healthcare systems to ensure equitable access to treatment and care. To achieve this goal, it is crucial to minimize the prevalence and disability-adjusted life years (DALYs) associated with chronic respiratory diseases by addressing modifiable risk factors such as smoking, air pollution, and occupational exposure to dust and chemicals.

The COVID-19 pandemic underscored the vulnerability of the lungs and the importance of respiratory health on a global scale. Beyond the direct effects of SARS-CoV-2, there has been increased attention to

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chronic respiratory diseases, as well as a greater emphasis on prevention, early diagnosis, and treatment in clinical settings[6]. Two previous studies have also reported a decrease in the incidence of non-COVID lower respiratory infections and tuberculosis during the COVID-19 pandemic[7,8]. As airway infections are major triggers for COPD exacerbations, they may similarly contribute to some of the changes observed in the chronic respiratory disease burden.

Hence, this study examined the trends and levels of the chronic respiratory disease burden before and during the COVID-19 pandemic. We also explored attributable risk factors globally and by region and Socio-demographic Index (SDI) between 1990 and 2023 across 204 countries and territories, using the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2023.

Results

Overview

Globally, in 2019, before the onset of the COVID-19 pandemic, we estimated 522.7 million (95% uncertainty interval (UI), 469.3–586.3) prevalent cases of chronic respiratory disease, corresponding to an age-standardized rate of 6,610.6 (5,926.5–7,459.7) per 100,000 population. In 2020, this rate remained stable (6,610.0 [5,917.4–7,464.6] per 100,000 population), indicating a plateau following the long-term decline in prevalence observed since 1990. However, this long-term downward trend reversed sharply thereafter; by 2023, the global prevalence rate had risen notably, reaching 6,742.2 (6,011.7–7,630.45) per 100,000 population. Across GBD regions in 2023, the age-standardized rate ranged from 4,216.9 per 100,000 in Central Asia to 15,186.4 per 100,000 in Australasia. Among 204 countries and territories, the age-standardized prevalence rate in 2023 ranged from 3,690.3 per 100,000 population in Mongolia to 16,884.8 per 100,000 population in New Zealand.

Among the four major chronic respiratory diseases, asthma accounted for more than half of chronic respiratory disease cases in 2023, with 362.7 million (309.8–427.6) cases and an age-standardized rate of 4,457.1 (3,786.4–5,246.3) per 100,000 population (Fig. 1). COPD ranked second, with 214.6 million (193.5–232.1) cases and an age-standardized rate of 2,373.0 (2,143.9–2,565.1) per 100,000 population. In 2023, the global age-standardized prevalence rate was 50.4 (45.0–56.7) per 100,000 population for ILD and pulmonary sarcoidosis and 11.2 (8.9–14.5) per 100,000 population for pneumoconiosis. The age-standardized prevalence rates for all diseases showed a minimal change from 1900 to 2023, with a percentage change ranging from −6.9% (−13.8 to 1.2) to 1.6% (0.2–3.0).

Chronic respiratory diseases were the fourth leading cause of death in 2023, accounting for 4.2 million (3.6–5.2) deaths. The global age-standardized death rate decreased from 63.0 per 100,000 population in 1990 to 46.8 per 100,000 population in 2023 (−25.7% (−40.0 to −2.0)). However, this trend was not universal; the Caribbean region showed a 15.6% (2.7–33.1) increase in age-standardized death rates over the same period (Fig. 2 and Table 1). COPD remained the leading contributor to the mortality burden, accounting for 82.3% of the deaths due to all chronic respiratory diseases (Supplementary Table 1 and Fig. 3). Asthma ranked second, accounting for 10.6% of the mortality cases. From 1990 to 2023, pneumoconiosis showed the most substantial decline in age-standardized mortality rates, with a reduction of −42.4% (−63.9 to −21.1). In contrast, the age-standardized mortality rates for ILD and pulmonary sarcoidosis increased by 89.2% (25.1–140.0), marking them as the only chronic respiratory disease with rising mortality trends during this period. Further details on the age-standardized estimates by region can be found in Extended Data Figs. 1–5 and Supplementary Table 1.

Trends in age and sex-specific burden

Figure 3 presents the trends in age and sex-specific death rates for four chronic respiratory diseases from 1990 to 2023. For COPD, age-specific death rates were higher in males across all age groups. Males aged 50 to 74 years had the greatest reduction of 49.1%, from 170.8 per 100,000 population in 1990 to 87.0 per 100,000 population in 2023, among all age-sex groups. For asthma, death rates remained stable for most age-sex groups, whereas males aged 0 to 14 years were the only age-sex group with a decline (1.3 per 100,000 population in 1990; 0.6 per 100,000 in 2023; −53.3% (−74.9 to −7.9)). Pneumoconiosis also showed stable trends for females and declining trends for males. Males had a greater mortality burden than females of all ages, and this gap became larger with advanced age. Last, age-sex-specific death rates for ILD and pulmonary sarcoidosis increased in most groups, most pronounced in those aged ≥75 years, with an increase of 158.8% in females and 137.4% in males from 1990 to 2023. Details on the global age and sex distributions of COPD, asthma, pneumoconiosis, ILD and pulmonary sarcoidosis prevalence and death are shown in Extended Data Figs. 6–8.

Disease burden before and during the COVID-19 pandemic

We examined the average annual percentage change (AAPC) in age-standardized incidence and death rates before (2010-2019) and during the COVID-19 pandemic (2020-2023). Globally, age-standardized incidence rates of chronic respiratory diseases remained relatively stable, with a slight increase from an AAPC of 0.05 before the pandemic to 0.13 during the pandemic. In contrast, the AAPC of age-standardized death rates of chronic respiratory diseases showed a more pronounced decreasing trend during the pandemic (AAPC, −3.04) compared with before the pandemic (AAPC, −1.23; Extended Data Fig. 9). This pattern in mortality trends was also observed for COPD, for which the AAPC in deaths changed from −1.34 to −3.27. Similarly, asthma showed a shift in death rates from −1.26 to −1.92, whereas asthma remained stable (AAPC: 0.20 before the pandemic, 0.21 during the pandemic). Pneumoconiosis showed a reversing trend in mortality from a decline before the pandemic (AAPC, −1.26) to a minimal increase (AAPC, 0.21) during the pandemic, whereas its incidence consistently decreased over the past decade. For ILD and pulmonary sarcoidosis, mortality trends reversed from a modest increase (AAPC, 1.05) to a slight decline (AAPC, −1.99; Fig. 4).

Risk factors for COPD, asthma and pneumoconiosis

In GBD 2023, risk factor estimation is available for COPD, asthma and pneumoconiosis (Fig. 5). For COPD, smoking remained the leading global risk factor for males, accounting for over half of the global age-standardized DALY rates (473.0 (379.0–603.4) per 100,000 population). In contrast, ambient particulate matter pollution was the leading risk factor for females globally (143.7 (103.9–198.0)) and in some regions, including Andean Latin America, Central Asia, Central Latin America, East Asia, North Africa and Middle East and Southern Sub-Saharan Africa. Ambient particulate matter ($PM_{2.5}$) pollution was a substantial risk factor for COPD for both sexes, consistently ranking high across multiple regions. Regional disparities were observed in the rankings of other COPD risk factors. For instance, although low temperature ranked seventh out of eight major risk factors for COPD globally for males and sixth for females, it was a prominent risk factor in Australasia, Western Europe and high-income North America for both sexes.

For asthma, high body mass index (BMI) was the leading global risk factor for age-standardized DALY rates globally (39.0 (19.3–63.8) per 100,000 population in males; 56.2 (25.5–92.9) in females) and in most regions for both sexes. Although the rankings of asthma risk factors were consistent across regions, the proportion of DALYs associated with high BMI was higher in regions such as North Africa and Middle East, and high-income North America than the global estimate. Occupational asthmagens, substances in the workplace that can trigger asthma, ranked second globally and across most regions for both males and females. For pneumoconiosis, occupational exposure to silica was the top global risk factor for males (7.9 (5.9–10.2)

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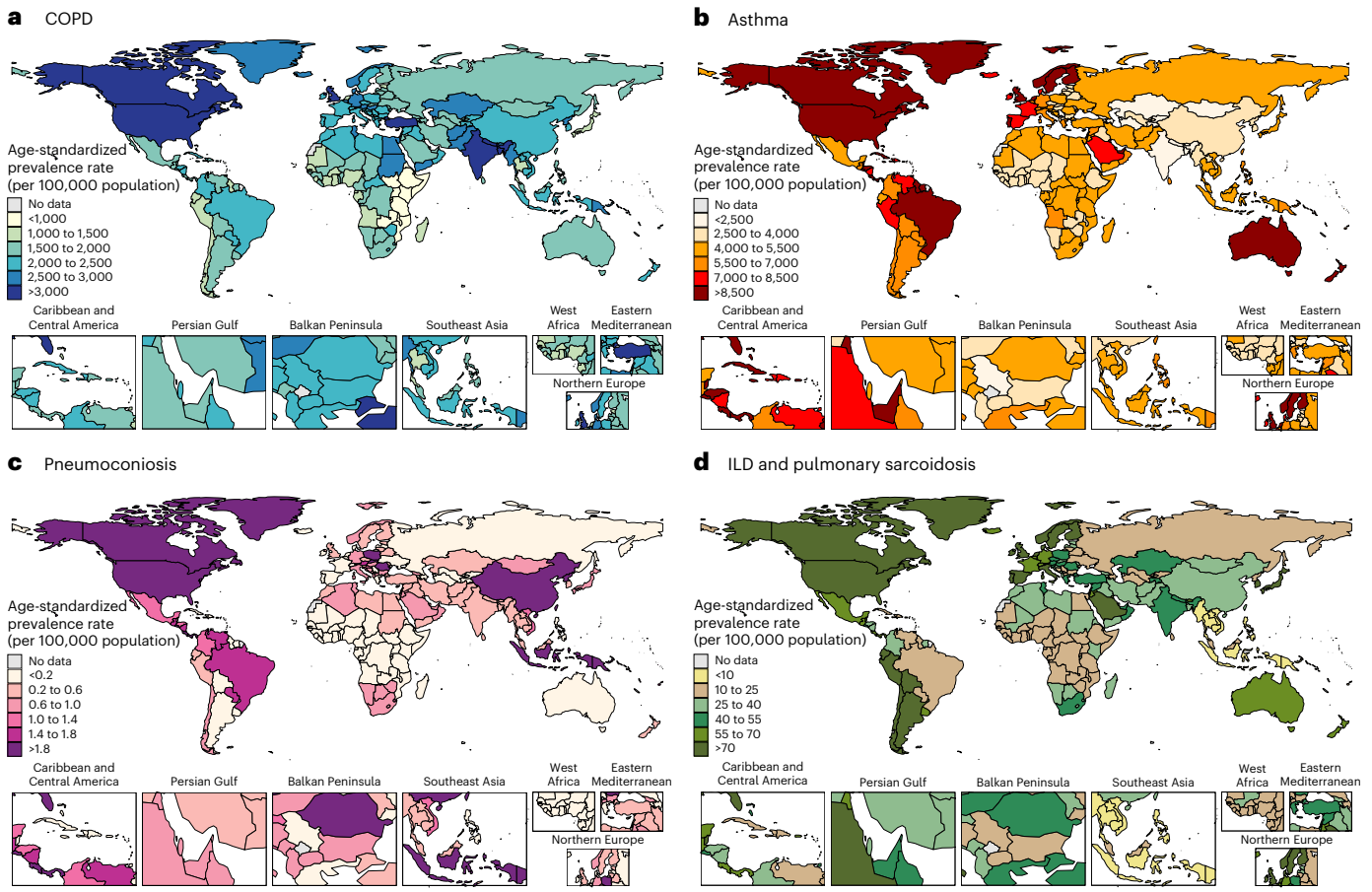

Fig. 1 | World map of age-standardized prevalence rates for COPD, asthma, pneumoconiosis, ILD and pulmonary sarcoidosis in 2023. a–d, World map depicting the 2023 age-standardized prevalence rates for COPD (**a**), asthma (**b**), pneumoconiosis (**c**) and ILD and pulmonary sarcoidosis (**d**). The color gradient, ranging from dark blue, red, purple or green (high value) to pale yellow (low value), indicates the magnitude of each metric. The small insets beneath the main map provide magnified views of the Caribbean and Central America, the Persian Gulf, the Balkan Peninsula, Southeast Asia, West Africa, the Eastern Mediterranean and Northern Europe.

per 100,000 population), whereas it ranked second for females (0.35 (0.20–0.62)). Occupational particulate matter, gases and fumes were the second leading global risk factor for males (2.5 (1.8–3.4) per 100,000 population) but ranked first for females (0.45 (0.25–0.86)).

Discussion

We provided estimates of chronic respiratory disease burden at the global, regional, and national levels from 1990 to 2023. Although global age-standardized incidence rates for chronic respiratory disease increased modestly during the COVID-19 pandemic, the age-standardized mortality rates, which had been declining before the pandemic, showed a reversal and began to rise during the pandemic period. Despite notable progress in reducing the global age-standardized death rate, the Caribbean region has shown a considerable increase of 15.6% from 1990 to 2023, particularly in ILD and pulmonary sarcoidosis. We further observed that this progress substantially varied by age; individuals aged <15 years had the greatest reductions, primarily in deaths due to asthma, whereas those aged ≥75 years had the most minor declines or even increases in some diseases, such as ILD and pulmonary sarcoidosis. Smoking, high BMI and occupational exposure to silica were leading risk factors for COPD, asthma and pneumoconiosis, respectively. Disparities in key risk factors according to SDI levels were observed; for instance, household air pollution from solid fuels was a key risk factor for COPD among females and in low-SDI settings, highlighting that region- and demography-specific public health measures are warranted to mitigate the disease burden effectively.

Globally, substantial progress has been made in reducing the burden of asthma, COPD and pneumoconiosis. This achievement may partly be attributed to various efforts to improve prevention and therapeutics through targeted strategies and actions[5]. For instance, the adoption of the World Health Organization Framework Convention on Tobacco Control in 2005, which includes raising taxes on tobacco and enforcing a ban on advertising, marked a turning point for enhancing global tobacco control efforts in the prevention of chronic respiratory diseases, from which smoking is a major risk factor[9]. Considering that some resource-limited countries have shown slow implementation of policies[9], there is potential for further reduction in the disease burden through improvements in preventive measures and treatment accessibility, as well as enhanced patient education on managing chronic respiratory diseases. In the past two decades, innovations in targeted therapies have contributed to a better prognosis for patients with chronic respiratory conditions. Novel targeted treatments, such as anti-IgE or anti-IL-5 monoclonal antibodies, represent a substantial advancement for patients with asthma refractory to conventional treatments, which could further contribute to a reduction in premature deaths[10]. For severe COPD, triple therapy, a combination of a long-acting muscarinic antagonist, a long-acting beta-agonist and an inhaled corticosteroid in a single inhaler, has shown improved outcomes[11].

Nevertheless, global age-standardized death rates from ILD and pulmonary sarcoidosis have substantially increased from 1990 to 2023. This may be due to the relatively recent recognition of the disease

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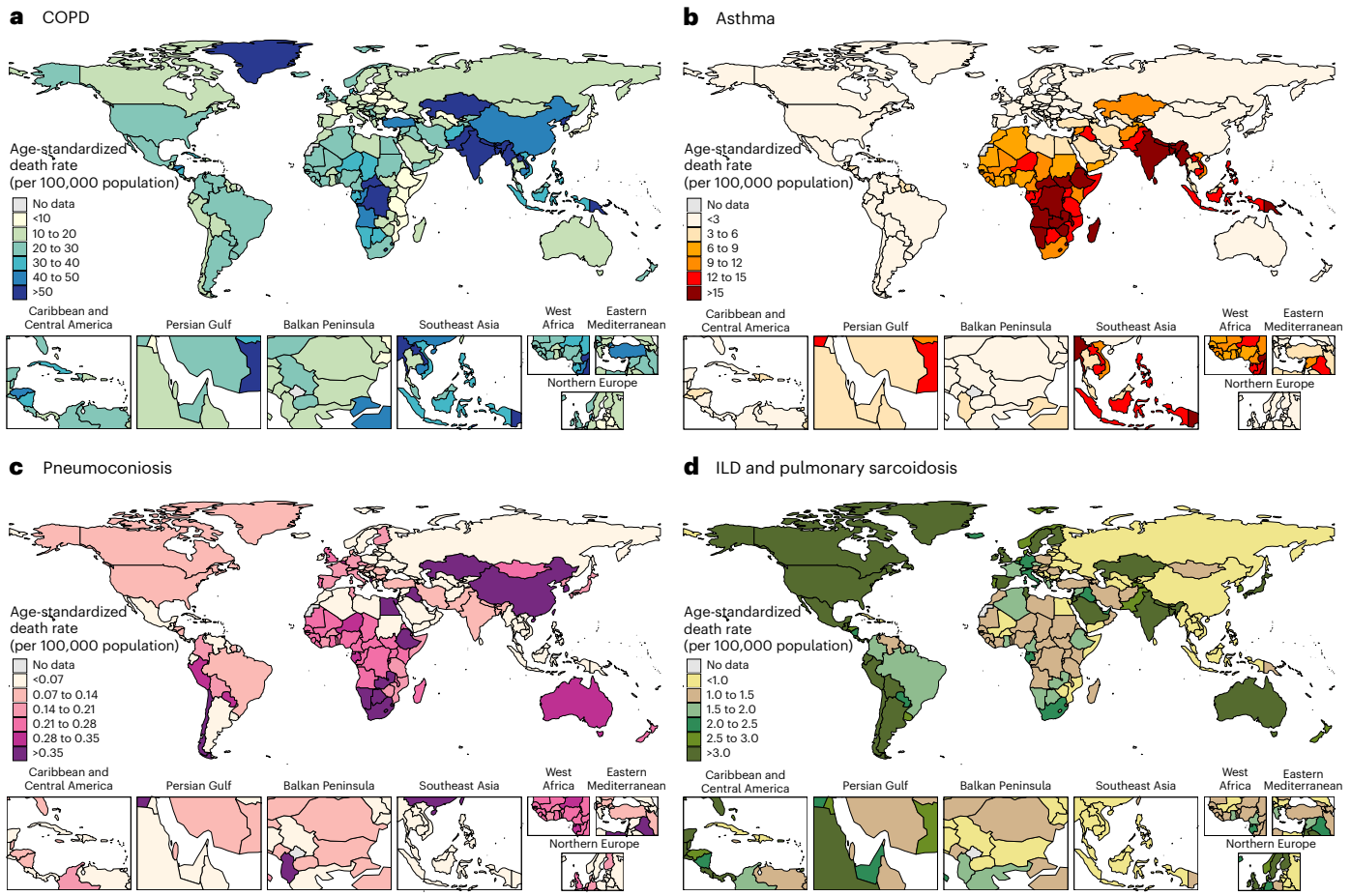

Fig. 2 | World map of age-standardized death rates for COPD, asthma, pneumoconiosis, ILD and pulmonary sarcoidosis in 2023. a–**d**, World map depicting the 2023 age-standardized death rates for COPD (**a**), asthma (**b**), pneumoconiosis (**c**) and ILD and pulmonary sarcoidosis (**d**). The color gradient, ranging from dark blue, red, purple or green (high value) to pale yellow (low value), indicates the magnitude of each metric. The small insets beneath the main map provide magnified views of the Caribbean and Central America, the Persian Gulf, the Balkan Peninsula, Southeast Asia, West Africa, the Eastern Mediterranean and Northern Europe.

compared to asthma and COPD[12]. Advances in radiology and pathology might have increased recognition and more accurate diagnosis of ILD and pulmonary sarcoidosis[13]. Moreover, the broader use of antimetabolites and cytotoxic agents—known to contribute to lung tissue scarring—has likely influenced this rise in ILD burden, especially among the older population[14].

Australasia had the highest age-standardized prevalence rate of chronic respiratory diseases, which is primarily due to asthma. Asthma has been historically more common in Western countries due to a complex interplay of genetic and environmental factors[15]. In addition, high-income North America exhibited the largest increase in age-standardized mortality rates for ILD and pulmonary sarcoidosis rose markedly, whereas those for asthma and pneumoconiosis experienced declines. This trend is also evident in other high-income regions, such as high-income North America and Western Europe (Fig. 2), suggesting heightened recognition and clinical awareness of these diseases in these countries, where advances in diagnostic technologies and improved healthcare infrastructure have led to better identification of previously underdiagnosed conditions[12]. Additionally, genetic and ethnic factors may also contribute to the rising mortality of pulmonary sarcoidosis[16]. Furthermore, Australasia had the highest age-standardized rate of chronic respiratory diseases in 2023 but ranked lower in age-standardized mortality rates (Fig. 2), likely due to advances in diagnostic measures and improvements in disease management and chronic disease care. In contrast, South Asian countries, such as India and Pakistan, despite having a lower age-standardized prevalence rate, ranked higher in age-standardized mortality rates, which may be attributed to limited access to early diagnosis and timely treatment compared to high-income countries.

The higher death rates of COPD, pneumoconiosis, ILD and pulmonary sarcoidosis in males than females, which are especially pronounced in advanced age, can be attributed to several factors, including more notable physiological lung function impairment with aging, historically higher smoking rates and greater occupational exposure to potential irritants in males[17]. However, the prevalence and mortality rates of asthma were both higher in female adults, resulting from the transition of sex discordance in prevalence, which reverses with puberty[17]. This difference may be due to the influence of sex hormones. Androgens can improve bronchodilation and attenuate airway inflammation[18], whereas hormonal fluctuations during menstruation, pregnancy and menopause can increase the risk in women[17].

During the COVID-19 pandemic, we observed a rise in age-standardized incidence rates of chronic respiratory diseases, which may be driven by enhanced healthcare engagement and high priority placed on respiratory health in clinical settings[6]. Individuals affected by COVID-19 or risk factors[19] may have prompted more frequent hospital visits, along with the increased number of CT scans performed[20], which has led to incidental diagnoses of underlying conditions, such as asthma or COPD[21]. This increased healthcare engagement and heightened awareness and monitoring of pulmonary health during

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Table 1 | Global and regional age-standardized mortality rates from chronic respiratory diseases in 1990, 2019, 2020 and 2023, and the percentage change from 1990 to 2023 for both sexes combined

Location	1990	2019	2020	2023	Percentage change (1990–2023)
Chronic respiratory disease					
Global	62.97 (50.04–72.28)	47.24 (41.75–56.19)	42.78 (37.29–51.27)	46.79 (40.56–57.70)	−25.68 (−40.00 to −1.97)
Central Asia	39.66 (36.34–43.24)	40.76 (37.49–43.54)	39.27 (36.54–41.64)	34.31 (31.31–38.53)	−13.49 (−22.24 to −3.67)
Central Europe	37.62 (35.51–39.32)	18.51 (17.29–19.85)	17.21 (16.11–18.17)	16.38 (15.20–17.84)	−56.47 (−58.88 to −53.21)
Eastern Europe	32.58 (29.95–35.56)	13.44 (12.45–14.42)	13.27 (12.31–14.25)	12.64 (11.34–13.67)	−61.22 (−65.37 to −56.84)
Australasia	36.30 (34.01–37.82)	24.04 (21.29–25.83)	21.89 (19.32–23.57)	22.85 (20.08–24.89)	−37.04 (−41.43 to −32.95)
High-income Asia Pacific	24.07 (21.60–26.71)	12.57 (10.71–14.63)	11.81 (10.04–13.41)	14.28 (11.72–17.42)	−40.67 (−49.12 to −26.34)
High-income North America	30.87 (28.61–32.54)	36.69 (32.67–39.85)	34.59 (30.91–37.57)	33.36 (29.63–36.47)	8.06 (−0.69 to 16.44)
Southern Latin America	34.28 (31.92–36.32)	29.52 (27.17–31.71)	24.98 (22.77–26.86)	27.43 (23.81–32.43)	−19.98 (−28.80 to −4.66)
Western Europe	30.09 (27.90–31.49)	22.43 (19.93–24.25)	20.50 (18.36–22.14)	21.19 (18.64–23.36)	−29.57 (−34.55 to −23.60)
Andean Latin America	31.38 (26.81–36.98)	29.51 (25.63–32.86)	25.16 (20.78–28.68)	32.47 (27.86–36.90)	3.49 (−14.13 to 20.84)
Caribbean	24.08 (21.98–26.19)	25.17 (23.03–27.64)	23.49 (21.41–25.94)	27.82 (25.02–31.70)	15.56 (2.65–33.11)
Central Latin America	43.39 (41.00–45.25)	31.37 (28.49–33.82)	27.94 (26.09–29.42)	28.27 (25.55–31.48)	−34.86 (−39.34 to −28.21)
Tropical Latin America	47.33 (42.75–51.36)	31.20 (28.24–33.31)	29.17 (26.18–30.75)	29.01 (25.90–30.96)	−38.71 (−43.28 to −34.54)
North Africa and Middle East	48.38 (31.31–65.03)	36.93 (30.83–44.19)	33.25 (27.25–39.51)	35.00 (28.51–42.95)	−27.65 (−49.32 to 10.35)
South Asia	138.62 (100.32–172.88)	120.30 (101.45–137.18)	106.03 (84.23–123.43)	120.81 (99.95–148.17)	−12.85 (−34.79 to 22.99)
East Asia	114.13 (78.38–148.38)	49.85 (41.31–66.32)	45.10 (36.57–61.55)	48.53 (37.77–68.60)	−57.48 (−71.95 to −26.65)
Oceania	141.27 (106.27–186.45)	111.55 (87.60–139.64)	107.25 (83.33–134.84)	109.94 (84.66–141.31)	−22.18 (−43.36 to 7.40)
Southeast Asia	70.08 (54.71–88.61)	49.74 (41.39–62.82)	45.75 (37.21–57.04)	48.10 (40.09–61.10)	−31.35 (−49.39 to −8.98)
Central Sub-Saharan Africa	90.74 (64.62–124.05)	77.06 (58.09–99.85)	74.20 (55.72–96.38)	71.81 (54.84–96.40)	−20.86 (−44.27 to 14.00)
Eastern Sub-Saharan Africa	32.38 (23.82–43.09)	30.33 (23.42–39.02)	28.07 (21.07–35.21)	28.05 (21.03–37.45)	−13.39 (−43.16 to 28.12)
Southern Sub-Saharan Africa	54.52 (43.12–66.69)	49.08 (42.29–60.62)	39.26 (31.58–48.38)	44.88 (38.30–56.36)	−17.69 (−36.90 to 2.14)
Western Sub-Saharan Africa	45.29 (33.58–59.17)	35.77 (27.48–45.85)	33.27 (25.69–42.91)	33.16 (25.28–45.14)	−26.78 (−51.32 to 5.34)
COPD					
Global	52.42 (41.57–60.13)	38.78 (33.61–46.16)	34.92 (29.97–42.11)	38.42 (33.18–45.77)	−26.71 (−40.77 to −1.85)
Central Asia	29.87 (27.31–32.81)	32.05 (29.39–34.30)	30.17 (27.88–32.12)	26.02 (23.41–29.44)	−12.89 (−23.62 to −0.55)
Central Europe	31.03 (29.31–32.60)	16.36 (15.32–17.45)	15.07 (14.07–15.85)	14.25 (13.20–15.45)	−54.08 (−56.83 to −50.87)
Eastern Europe	27.23 (25.21–29.78)	12.42 (11.52–13.32)	12.21 (11.31–13.10)	11.60 (10.45–12.53)	−57.41 (−62.10 to −52.50)
Australasia	29.63 (27.72–30.87)	18.81 (16.57–20.25)	16.91 (14.84–18.24)	17.71 (15.56–19.29)	−40.23 (−44.46 to −36.18)
High-income Asia Pacific	14.25 (12.31–15.70)	6.80 (5.80–7.89)	6.21 (5.24–7.08)	7.65 (6.23–9.32)	−46.30 (−53.56 to −33.34)
High-income North America	26.26 (24.30–27.70)	30.82 (27.39–33.66)	28.84 (25.68–31.39)	27.70 (24.47–30.26)	5.45 (−2.19 to 13.70)
Southern Latin America	27.78 (25.75–29.64)	22.75 (20.83–24.57)	19.11 (17.48–20.67)	20.85 (18.02–24.49)	−24.93 (−34.23 to −10.32)
Western Europe	24.34 (22.61–25.60)	18.38 (16.35–19.86)	16.69 (14.90–17.99)	17.25 (15.21–18.98)	−29.12 (−34.00 to −23.04)
Andean Latin America	17.03 (14.38–20.25)	12.72 (10.93–15.17)	10.71 (8.97–13.20)	13.57 (11.41–16.85)	−20.33 (−34.76 to −1.05)
Caribbean	17.31 (15.70–18.86)	19.85 (18.10–21.57)	18.27 (16.63–20.06)	22.13 (19.89–25.18)	27.81 (14.24–47.39)
Central Latin America	34.32 (32.34–35.76)	26.53 (23.99–28.57)	23.37 (21.66–24.66)	23.38 (21.03–26.03)	−31.87 (−36.52 to −25.17)
Tropical Latin America	42.80 (38.63–46.54)	27.35 (24.60–29.20)	25.30 (22.65–26.66)	25.27 (22.40–26.99)	−40.96 (−45.16 to −36.85)
North Africa and Middle East	33.08 (20.15–45.63)	28.12 (23.74–33.36)	25.34 (20.55–30.08)	26.67 (21.31–32.37)	−19.36 (−45.17 to 30.46)
South Asia	111.38 (77.49–143.62)	98.93 (78.84–116.81)	86.88 (66.23–105.35)	99.97 (81.38–123.57)	−10.24 (−33.36 to 26.77)
East Asia	110.60 (74.61–143.73)	47.43 (39.17–63.38)	42.74 (34.63–58.26)	46.24 (35.83–65.87)	−58.20 (−72.62 to −26.56)
Oceania	110.94 (75.62–148.51)	89.37 (66.90–113.90)	85.76 (62.70–110.81)	89.07 (62.35–118.12)	−19.72 (−41.92 to 14.30)
Southeast Asia	50.02 (37.70–64.36)	35.40 (29.21–41.98)	32.24 (25.10–39.25)	34.29 (27.29–41.94)	−31.46 (−50.49 to −10.26)
Central Sub-Saharan Africa	66.88 (43.19–95.89)	57.31 (40.32–76.49)	55.12 (38.77–74.31)	53.88 (37.33–76.41)	−19.43 (−45.11 to 17.21)
Eastern Sub-Saharan Africa	11.38 (4.75–18.99)	11.01 (5.00–16.31)	10.05 (5.00–15.35)	10.31 (5.04–16.28)	−9.38 (−49.63 to 65.93)
Southern Sub-Saharan Africa	35.62 (26.81–46.07)	32.04 (27.14–38.85)	24.98 (19.86–31.48)	28.77 (23.61–35.87)	−19.23 (−39.71 to 4.79)
Western Sub-Saharan Africa	27.65 (18.74–41.09)	23.65 (16.97–32.23)	21.76 (15.82–29.91)	21.95 (15.19–30.35)	−20.60 (−51.25 to 18.85)

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Table 1 (continued) | Global and regional age-standardized mortality rates from chronic respiratory diseases in 1990, 2019, 2020 and 2023, and the percentage change from 1990 to 2023 for both sexes combined

Location	1990	2019	2020	2023	Percentage change (1990–2023)
Asthma					
Global	7.93 (5.07–11.62)	5.20 (3.77–7.55)	4.75 (3.46–6.90)	4.98 (3.46–7.45)	−37.22 (−61.34 to −3.06)
Central Asia	7.41 (6.07–9.04)	6.20 (5.35–7.06)	6.32 (5.44–7.27)	5.33 (4.50–6.26)	−28.06 (−42.16 to −9.77)
Central Europe	4.67 (4.17–5.15)	0.91 (0.78–1.15)	0.91 (0.79–1.10)	0.86 (0.75–1.09)	−81.50 (−84.23 to −77.05)
Eastern Europe	3.83 (3.29–4.39)	0.48 (0.43–0.54)	0.47 (0.42–0.53)	0.40 (0.34–0.47)	−89.49 (−91.32 to −87.14)
Australasia	4.17 (3.89–4.44)	1.17 (1.04–1.31)	1.08 (0.96–1.20)	1.04 (0.90–1.16)	−75.05 (−78.33 to −72.17)
High-income Asia Pacific	6.20 (4.42–7.66)	0.67 (0.45–1.34)	0.60 (0.41–1.21)	0.64 (0.40–1.39)	−89.65 (−94.17 to −72.21)
High-income North America	1.65 (1.48–1.82)	0.84 (0.74–0.94)	0.89 (0.78–1.00)	0.79 (0.70–0.88)	−52.30 (−59.22 to −44.97)
Southern Latin America	2.32 (1.95–2.67)	0.94 (0.84–1.05)	0.84 (0.74–0.94)	0.83 (0.70–0.98)	−64.28 (−70.48 to −56.08)
Western Europe	3.07 (2.79–3.38)	0.70 (0.62–0.79)	0.66 (0.57–0.73)	0.65 (0.57–0.73)	−78.76 (−81.30 to −75.87)
Andean Latin America	3.35 (2.53–4.45)	0.90 (0.70–1.29)	0.78 (0.59–1.10)	0.92 (0.67–1.35)	−72.59 (−82.04 to −55.32)
Caribbean	4.77 (3.86–5.70)	3.14 (2.56–4.10)	3.08 (2.45–4.01)	3.31 (2.70–4.31)	−30.63 (−46.42 to −10.35)
Central Latin America	5.98 (5.52–6.49)	1.14 (1.01–1.36)	1.15 (1.02–1.34)	1.09 (0.95–1.32)	−81.81 (−84.40 to −78.01)
Tropical Latin America	2.74 (2.40–3.12)	1.19 (1.08–1.31)	1.19 (1.07–1.29)	1.17 (1.07–1.27)	−57.47 (−62.07 to −51.62)
North Africa and Middle East	12.85 (5.94–20.26)	6.29 (4.49–8.60)	5.61 (3.85–7.69)	5.77 (3.99–8.13)	−55.09 (−74.56 to −4.65)
South Asia	23.24 (10.73–48.05)	16.33 (9.50–28.61)	14.37 (8.72–25.11)	15.40 (8.43–26.91)	−33.72 (−66.43 to 31.67)
East Asia	2.61 (1.32–4.23)	1.25 (0.90–2.04)	1.19 (0.76–2.02)	1.14 (0.72–1.94)	−56.46 (−78.26 to 14.42)
Oceania	27.66 (15.07–45.30)	19.47 (11.76–31.58)	18.82 (11.43–30.55)	18.13 (10.61–32.19)	−34.46 (−62.54 to 5.43)
Southeast Asia	19.10 (11.87–28.60)	13.16 (9.32–20.19)	12.36 (8.79–19.48)	12.58 (8.90–19.50)	−34.11 (−62.54 to 11.79)
Central Sub-Saharan Africa	21.08 (9.11–36.81)	16.91 (8.33–28.31)	16.28 (8.55–27.42)	15.15 (7.51–25.58)	−28.14 (−60.38 to 26.34)
Eastern Sub-Saharan Africa	18.29 (9.94–28.86)	16.33 (10.21–24.75)	15.18 (9.26–22.70)	14.79 (9.18–23.26)	−19.11 (−49.97 to 32.19)
Southern Sub-Saharan Africa	15.87 (10.28–22.93)	13.46 (10.98–18.33)	11.25 (8.34–15.36)	12.58 (9.55–16.44)	−20.74 (−48.51 to 24.17)
Western Sub-Saharan Africa	14.59 (8.78–21.66)	9.36 (6.10–13.51)	8.86 (5.70–12.64)	8.51 (5.56–13.22)	−41.64 (−65.99 to −0.39)
Pneumoconiosis					
Global	0.36 (0.27–0.49)	0.22 (0.18–0.26)	0.21 (0.17–0.25)	0.21 (0.16–0.28)	−42.41 (−63.88 to −21.13)
Central Asia	0.20 (0.12–0.29)	0.20 (0.16–0.26)	0.19 (0.15–0.25)	0.14 (0.11–0.18)	−29.13 (−55.74 to 26.46)
Central Europe	0.43 (0.37–0.50)	0.09 (0.08–0.10)	0.09 (0.07–0.09)	0.08 (0.07–0.09)	−81.66 (−84.96 to −77.87)
Eastern Europe	0.09 (0.07–0.14)	0.06 (0.05–0.07)	0.05 (0.04–0.07)	0.04 (0.04–0.06)	−53.62 (−70.65 to −26.05)
Australasia	0.20 (0.18–0.23)	0.30 (0.26–0.34)	0.28 (0.25–0.32)	0.28 (0.24–0.32)	37.34 (13.08–63.25)
High-income Asia Pacific	0.56 (0.44–0.68)	0.22 (0.18–0.26)	0.21 (0.17–0.25)	0.22 (0.17–0.28)	−60.40 (−72.04 to −45.54)
High-income North America	0.37 (0.32–0.42)	0.11 (0.09–0.14)	0.11 (0.09–0.13)	0.10 (0.08–0.12)	−73.53 (−79.82 to −66.26)
Southern Latin America	0.31 (0.24–0.39)	0.15 (0.13–0.17)	0.13 (0.11–0.14)	0.13 (0.10–0.17)	−60.12 (−72.86 to −42.40)
Western Europe	0.66 (0.58–0.74)	0.17 (0.15–0.19)	0.16 (0.14–0.18)	0.15 (0.13–0.18)	−77.26 (−80.99 to −72.75)
Andean Latin America	0.22 (0.12–0.38)	0.29 (0.22–0.41)	0.24 (0.18–0.32)	0.30 (0.21–0.43)	38.50 (−32.41 to 148.10)
Caribbean	0.04 (0.03–0.06)	0.03 (0.02–0.04)	0.03 (0.02–0.04)	0.03 (0.02–0.04)	−30.13 (−55.88 to 2.60)
Central Latin America	0.31 (0.25–0.38)	0.09 (0.08–0.10)	0.08 (0.07–0.10)	0.08 (0.06–0.09)	−75.41 (−81.14 to −67.26)
Tropical Latin America	0.16 (0.12–0.20)	0.17 (0.15–0.19)	0.16 (0.14–0.18)	0.15 (0.13–0.17)	−6.30 (−24.38 to 16.66)
North Africa and Middle East	0.15 (0.07–0.29)	0.15 (0.10–0.22)	0.13 (0.09–0.21)	0.14 (0.09–0.22)	−9.11 (−62.50 to 127.23)
South Asia	0.10 (0.03–0.26)	0.12 (0.05–0.24)	0.10 (0.04–0.21)	0.12 (0.05–0.23)	20.40 (−50.80 to 234.14)
East Asia	0.47 (0.18–1.03)	0.44 (0.33–0.56)	0.43 (0.30–0.56)	0.42 (0.28–0.58)	−10.71 (−65.84 to 150.83)
Oceania	0.01 (0.00–0.02)	0.01 (0.00–0.03)	0.01 (0.00–0.03)	0.01 (0.00–0.03)	47.02 (−50.31 to 346.72)
Southeast Asia	0.01 (0.01–0.03)	0.01 (0.01–0.02)	0.01 (0.01–0.02)	0.01 (0.01–0.02)	2.67 (−55.87 to 145.92)
Central Sub-Saharan Africa	0.29 (0.09–0.81)	0.28 (0.10–0.56)	0.27 (0.10–0.52)	0.26 (0.10–0.54)	−10.96 (−65.68 to 144.95)
Eastern Sub-Saharan Africa	0.26 (0.07–0.63)	0.30 (0.11–0.65)	0.28 (0.10–0.58)	0.28 (0.10–0.60)	6.41 (−60.91 to 209.76)
Southern Sub-Saharan Africa	0.39 (0.21–0.70)	0.42 (0.28–0.62)	0.35 (0.22–0.53)	0.40 (0.23–0.59)	2.31 (−52.61 to 119.59)
Western Sub-Saharan Africa	0.31 (0.08–0.75)	0.27 (0.09–0.55)	0.25 (0.09–0.53)	0.24 (0.08–0.56)	−21.30 (−66.26 to 131.72)

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Table 1 (continued) | Global and regional age-standardized mortality rates from chronic respiratory diseases in 1990, 2019, 2020 and 2023, and the percentage change from 1990 to 2023 for both sexes combined

Location	1990	2019	2020	2023	Percentage change (1990–2023)
ILD and pulmonary sarcoidosis					
Global	1.27 (1.00–2.04)	2.30 (1.93–2.80)	2.18 (1.84–2.69)	2.40 (1.98–2.93)	89.16 (25.10–139.76)
Central Asia	1.16 (0.93–1.40)	1.46 (1.23–1.78)	1.72 (1.46–2.07)	2.03 (1.66–2.44)	74.22 (35.91–120.94)
Central Europe	1.01 (0.88–1.16)	1.02 (0.93–1.11)	1.03 (0.93–1.13)	1.06 (0.96–1.16)	4.66 (−9.45 to 21.56)
Eastern Europe	0.87 (0.72–1.04)	0.36 (0.32–0.42)	0.41 (0.35–0.48)	0.49 (0.40–0.58)	−43.67 (−56.95 to −27.22)
Australasia	1.14 (1.03–1.25)	3.34 (2.96–3.67)	3.20 (2.84–3.50)	3.40 (3.00–3.76)	199.07 (164.24–231.85)
High-income Asia Pacific	2.73 (2.39–3.06)	4.62 (3.96–5.22)	4.53 (3.89–5.11)	5.48 (4.46–6.53)	100.85 (68.12–144.01)
High-income North America	2.23 (2.01–2.40)	4.38 (3.85–4.88)	4.21 (3.72–4.61)	4.25 (3.70–4.75)	90.91 (70.09–111.97)
Southern Latin America	2.60 (2.18–3.03)	5.09 (4.57–5.60)	4.36 (3.86–4.76)	5.06 (4.29–6.12)	94.80 (61.32–148.63)
Western Europe	1.08 (0.97–1.18)	2.93 (2.59–3.21)	2.76 (2.49–2.99)	2.89 (2.56–3.23)	168.56 (137.83–199.13)
Andean Latin America	5.94 (3.97–8.65)	14.58 (10.67–17.35)	12.53 (8.63–15.17)	16.56 (12.29–19.80)	178.80 (80.89–358.17)
Caribbean	0.59 (0.48–0.82)	1.14 (0.97–1.44)	1.08 (0.89–1.41)	1.31 (1.11–1.63)	123.14 (69.98–178.92)
Central Latin America	1.38 (1.26–1.53)	2.67 (2.48–2.88)	2.51 (2.32–2.68)	2.91 (2.62–3.28)	111.13 (89.20–138.14)
Tropical Latin America	0.92 (0.82–1.03)	1.92 (1.72–2.08)	1.94 (1.75–2.08)	1.85 (1.65–2.00)	100.70 (77.73–130.70)
North Africa and Middle East	1.07 (0.55–2.00)	1.51 (1.04–2.25)	1.39 (0.98–2.01)	1.57 (1.09–2.35)	46.89 (−39.34 to 166.77)
South Asia	2.33 (0.94–7.44)	3.51 (1.96–6.10)	3.35 (1.87–5.80)	3.79 (2.08–6.50)	62.44 (−31.81 to 236.71)
East Asia	0.19 (0.11–0.32)	0.47 (0.32–0.62)	0.47 (0.30–0.63)	0.47 (0.31–0.70)	153.05 (33.02–382.78)
Oceania	1.25 (0.71–2.31)	1.16 (0.65–2.00)	1.13 (0.64–2.00)	1.18 (0.61–1.98)	−5.44 (−53.70 to 47.71)
Southeast Asia	0.19 (0.07–0.42)	0.39 (0.16–0.84)	0.38 (0.16–0.83)	0.41 (0.15–0.91)	111.65 (−14.75 to 319.01)
Central Sub-Saharan Africa	1.28 (0.26–3.56)	1.39 (0.40–3.14)	1.38 (0.38–3.16)	1.37 (0.40–2.73)	6.61 (−50.75 to 118.56)
Eastern Sub-Saharan Africa	1.19 (0.20–3.02)	1.45 (0.46–2.98)	1.38 (0.44–2.82)	1.43 (0.45–2.77)	19.90 (−44.24 to 215.81)
Southern Sub-Saharan Africa	1.47 (0.79–2.27)	1.87 (1.33–2.70)	1.50 (1.04–2.17)	1.87 (1.27–2.76)	26.93 (−31.40 to 108.24)
Western Sub-Saharan Africa	1.35 (0.32–3.12)	1.32 (0.51–2.52)	1.27 (0.48–2.41)	1.28 (0.52–2.35)	−5.12 (−59.72 to 114.51)
Other chronic respiratory disease					
Global	0.98 (0.71–1.33)	0.74 (0.55–1.03)	0.72 (0.51–1.02)	0.79 (0.58–1.11)	−19.55 (−44.05 to 14.91)
Central Asia	1.01 (0.78–1.31)	0.85 (0.70–1.02)	0.87 (0.69–1.03)	0.78 (0.61–0.97)	−22.12 (−42.33 to 6.35)
Central Europe	0.47 (0.41–0.54)	0.13 (0.11–0.17)	0.12 (0.10–0.16)	0.12 (0.10–0.16)	−74.08 (−79.39 to −66.82)
Eastern Europe	0.56 (0.42–0.73)	0.12 (0.09–0.14)	0.12 (0.09–0.14)	0.11 (0.08–0.14)	−80.98 (−86.23 to −72.65)
Australasia	1.16 (1.02–1.34)	0.42 (0.36–0.48)	0.41 (0.35–0.47)	0.42 (0.35–0.48)	−63.87 (−70.86 to −55.84)
High-income Asia Pacific	0.34 (0.29–0.42)	0.25 (0.20–0.31)	0.25 (0.21–0.31)	0.29 (0.23–0.37)	−15.10 (−37.65 to 13.73)
High-income North America	0.36 (0.30–0.44)	0.54 (0.44–0.62)	0.54 (0.45–0.64)	0.53 (0.44–0.62)	45.71 (13.45–88.17)
Southern Latin America	1.28 (1.11–1.46)	0.58 (0.51–0.67)	0.54 (0.47–0.64)	0.57 (0.45–0.72)	−55.66 (−65.13 to −42.02)
Western Europe	0.94 (0.85–1.02)	0.24 (0.21–0.28)	0.24 (0.20–0.27)	0.24 (0.21–0.28)	−73.98 (−77.46 to −69.92)
Andean Latin America	4.83 (3.50–6.50)	1.02 (0.75–1.56)	0.89 (0.64–1.36)	1.12 (0.79–1.72)	−76.77 (−85.92 to −58.42)
Caribbean	1.37 (1.02–1.79)	1.01 (0.71–1.44)	1.02 (0.71–1.48)	1.04 (0.74–1.46)	−23.51 (−48.33 to 15.49)
Central Latin America	1.41 (1.26–1.57)	0.94 (0.84–1.04)	0.84 (0.74–0.93)	0.81 (0.72–0.92)	−42.37 (−49.84 to −32.67)
Tropical Latin America	0.71 (0.63–0.83)	0.58 (0.51–0.64)	0.58 (0.52–0.65)	0.58 (0.52–0.65)	−18.66 (−30.51 to −5.20)
North Africa and Middle East	1.23 (0.74–1.87)	0.85 (0.56–1.21)	0.78 (0.52–1.08)	0.85 (0.54–1.18)	−30.77 (−62.77 to 38.38)
South Asia	1.58 (0.83–3.18)	1.41 (0.87–2.42)	1.33 (0.77–2.31)	1.53 (0.94–2.55)	−2.98 (−47.94 to 70.26)
East Asia	0.25 (0.15–0.42)	0.27 (0.21–0.37)	0.26 (0.19–0.36)	0.26 (0.20–0.39)	3.33 (−42.55 to 103.65)
Oceania	1.42 (0.72–2.64)	1.53 (0.76–2.71)	1.53 (0.75–2.65)	1.56 (0.78–2.83)	10.25 (−45.15 to 141.79)
Southeast Asia	0.75 (0.47–1.19)	0.77 (0.44–1.18)	0.76 (0.44–1.15)	0.81 (0.46–1.27)	8.35 (−42.81 to 82.39)
Central Sub-Saharan Africa	1.21 (0.58–2.26)	1.17 (0.57–2.31)	1.15 (0.54–2.28)	1.15 (0.56–2.17)	−4.19 (−48.04 to 82.59)
Eastern Sub-Saharan Africa	1.26 (0.41–2.81)	1.23 (0.47–2.93)	1.19 (0.42–2.84)	1.23 (0.44–2.76)	−2.20 (−53.66 to 84.03)
Southern Sub-Saharan Africa	1.17 (0.76–1.75)	1.29 (0.89–1.79)	1.18 (0.79–1.64)	1.26 (0.85–1.76)	7.87 (−32.63 to 90.48)
Western Sub-Saharan Africa	1.40 (0.70–2.33)	1.18 (0.63–1.87)	1.14 (0.62–1.84)	1.17 (0.63–1.92)	−16.02 (−53.74 to 50.64)

Values in parentheses represent 95% uncertainty intervals.

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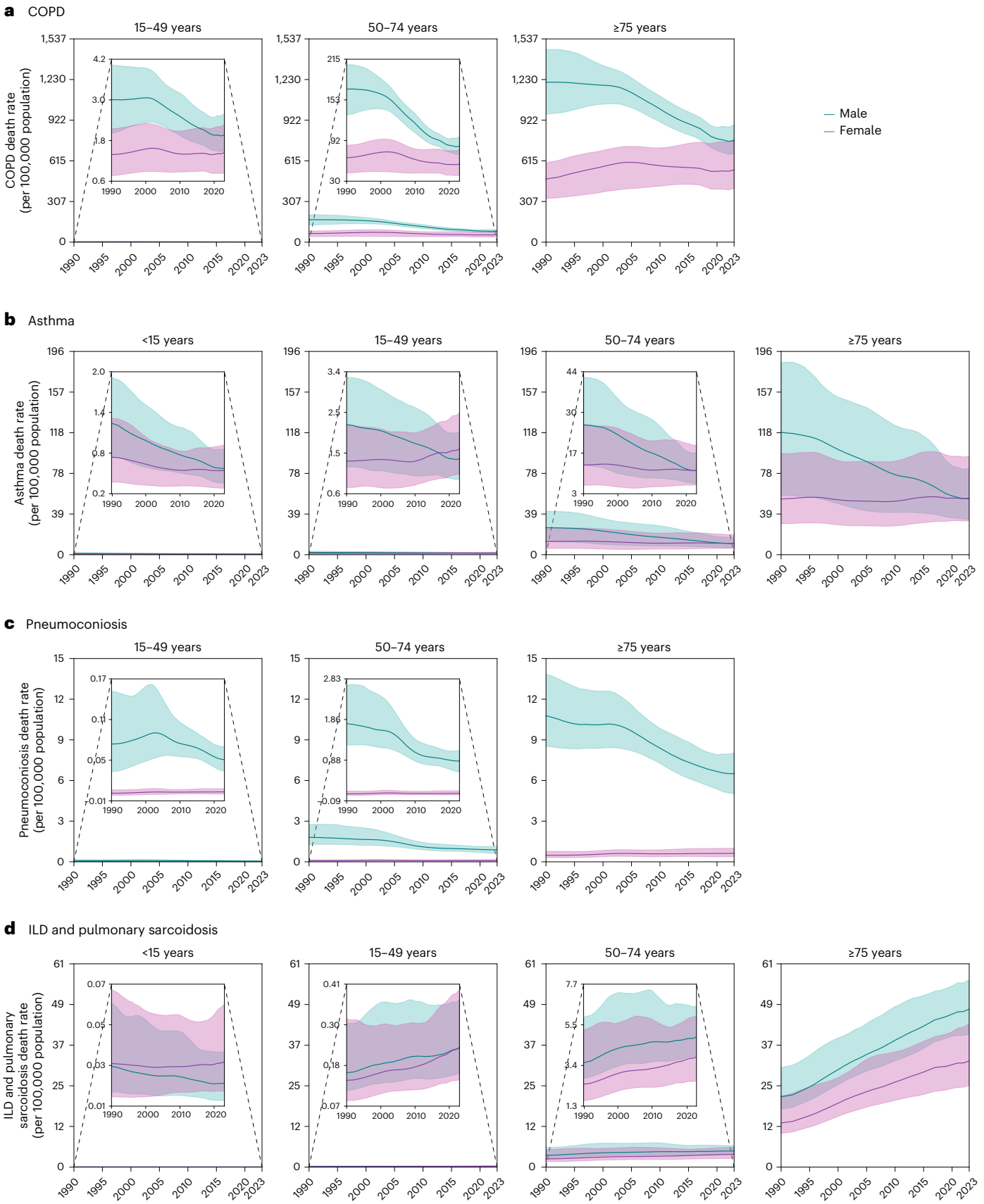

Fig. 3 | Global age-sex-specific COPD, asthma, pneumoconiosis, ILD and pulmonary sarcoidosis death rates, 1990–2023. a–**d**, The 1990–2023 global age- and sex-specific death rate trends for COPD (**a**), asthma (**b**), pneumoconiosis (**c**) and ILD and pulmonary sarcoidosis (**d**). Blue indicates males, and pink indicates females. The bold line represents the mean death rate (derived from the GBD 2023), and the lighter shading denotes the 95% UI. For age groups whose trends are not clearly visible due to *y*-axis scaling, inset figures are provided. These data are population-level estimates (no separate biological or technical replicates), and the unit of study is the entire population in each region-year. No control group was used, as this is an observational, population-based analysis.

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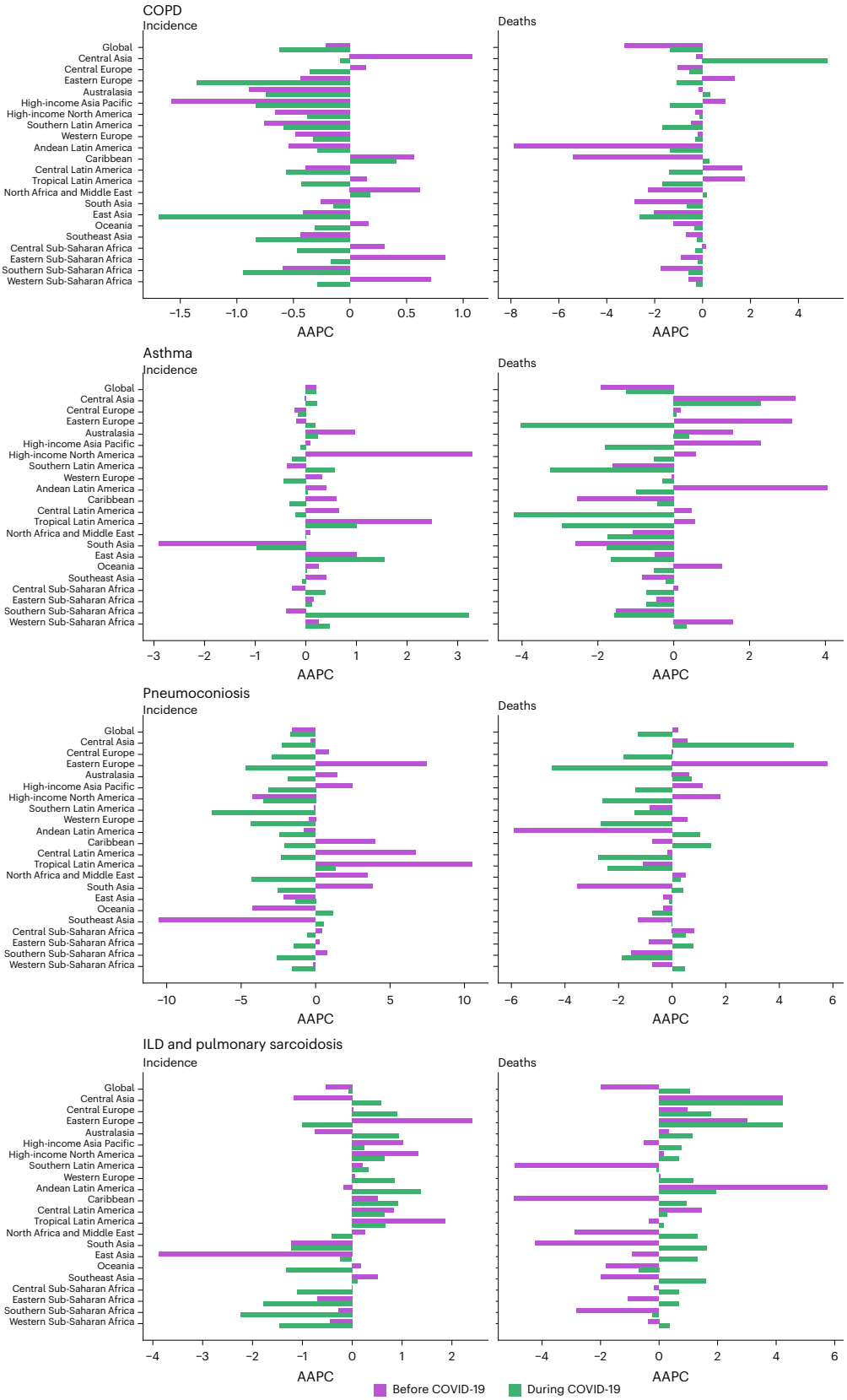

Fig. 4 | AAPC of age-standardized incidence and death rates for COPD, asthma, pneumoconiosis, ILD and pulmonary sarcoidosis by GBD region during the pre-COVID-19 (2010–2019) and pandemic period (2020–2023). AAPC in age-standardized incidence and death rates for COPD, asthma, pneumoconiosis, ILD and pulmonary sarcoidosis, divided into the pre-COVID-19 period (2010–2019) and the pandemic period (2020–2023). The *x*-axis represents the AAPC, and the *y*-axis indicates the GBD regions. The purple bars correspond to the AAPC during the pre-COVID-19 period (2010–2019), and the green bars correspond to the AAPC during the pandemic period (2020–2023). GBD, Global Burden of Disease, Injuries, and Risk Factors Study.

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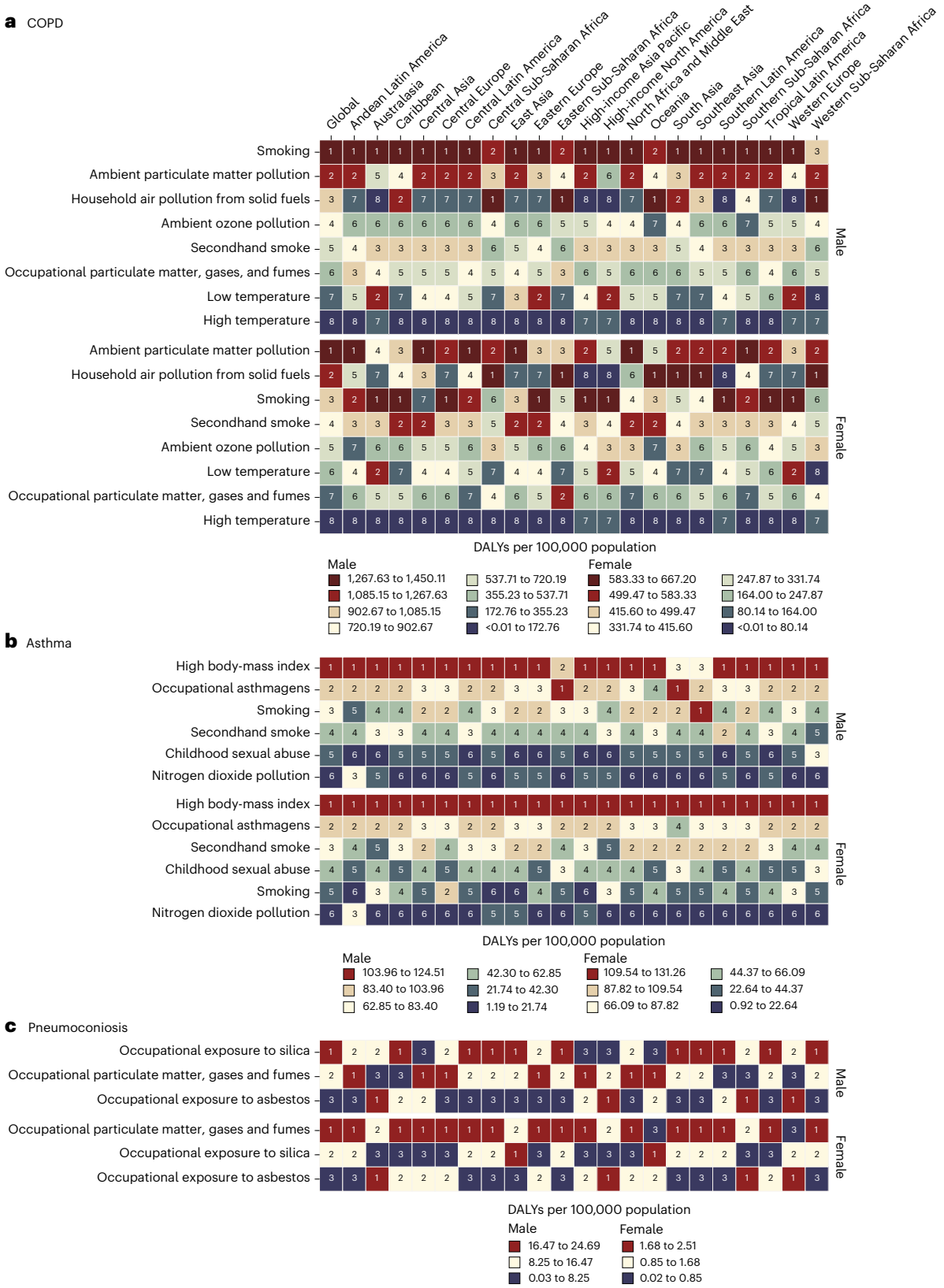

Fig. 5 | Global and regional distribution of age-standardized DALY rates for COPD, asthma, and pneumoconiosis by risk factor in males and females, 2023. Heatmap illustrating the 2023 age-standardized DALY rates rankings for risk factors associated with COPD (**a**), asthma (**b**) and pneumoconiosis (**c**). The *x*-axis shows global and GBD regions, and the *y*-axis lists disease-specific risk factors. In each heatmap, male data appear at the top, and female data appear at the bottom. The number in each cell represents the rank of risk factors associated with the disease. More detailed DALY rates for each disease-specific risk factor are provided in the legend at the bottom of each heatmap.

the pandemic might have contributed to better detection of previously undiagnosed cases.

Although age-standardized incidence rates for chronic respiratory diseases remained stable, age-standardized death rates, which had been declining steadily in the pre-pandemic period, began to rise. This reversal pattern of mortality rates could suggest that pandemic-related factors, such as exacerbations triggered by respiratory infections, offset some of the progress made in reducing chronic respiratory disease-related deaths. This is particularly evident for COPD, where the pandemic may have increased the frequency of exacerbations while still reducing mortality overall due to heightened healthcare focus[6,22,23]. In contrast, for ILD and pulmonary sarcoidosis, which had exhibited rising mortality trends before the pandemic, the observed deceleration in mortality increases may reflect changes in environmental exposures (for example, reduced occupational and outdoor pollutants) linked to pandemic-related behavioral shifts such as increased mask usage and reduced industrial activity[24,25].

Overall, the impact of the COVID-19 pandemic on chronic respiratory diseases is less pronounced than in tuberculosis and non-COVID-19 lower respiratory infections[7,8]. Unlike these acute conditions, the nature of chronic diseases may have made them less immediately affected by the pandemic. In addition, the interactions between COVID-19 and chronic respiratory diseases are complex and bidirectional. Individuals with a history of COVID-19 are more likely to develop a range of pulmonary sequelae[26,27], whereas those with pre-existing chronic respiratory diseases are more susceptible to severe COVID-19 outcomes as a result of infection[28,29]. These factors may lead to an underestimation of the true extent of excess mortality related to chronic respiratory diseases, as some of these cases may be recorded as COVID-19-related fatalities[30]. Therefore, further studies are needed to better understand the full impact of the COVID-19 pandemic on chronic respiratory diseases and clarify the factors contributing to variations in disease outcomes across different chronic respiratory diseases.

Although the burden of chronic respiratory disease remains large, they have received less attention compared to other major NCDs, such as cancer and cardiovascular diseases, in research[31]. Decreasing respiratory function is a natural part of the aging process; however, it can be delayed by dietary, behavioral and environmental approaches, which prevent additional exposure to risk factors[32]. Furthermore, as most chronic respiratory diseases are not fully curable, it is important to focus on prevention to mitigate the burden. This study provides estimates of modifiable risk factors contributing to chronic respiratory diseases globally and by SDI levels, which highlight the potential impact of health interventions in reducing disease burden and provide a strategic roadmap for targeting the most notable risk factors by region.

For instance, we noted that household air pollution from solid fuels, rather than smoking, was estimated to be the primary contributor to the COPD burden among females in low SDI regions. Therefore, using cleaner fuels or technology for domestic work is required to reduce solid fuel exposure in these countries[33], which aligns with the Clean Cooking Alliance, a leading global initiative to make clean cooking more accessible[34]. Enhancing access to modern energy for cooking is crucial to meet the United Nations' Sustainable Development Goal (SDG) by 2030, and this shift can reduce the disease burden, contribute to climate change mitigation, and protect terrestrial ecosystems. High DALY rates for asthma, COPD, and pneumoconiosis in low-SDI regions, despite lower prevalence, suggest that poor healthcare access, suboptimal treatment, and unhealthy environments amplify the burden[35]. Therefore, prevention, diagnostic, and therapeutic approaches for chronic respiratory diseases in limited-source settings should be addressed at a global level.

This study has several limitations, primarily due to the limited availability of data and high variability in input data across regions. First, despite the use of international vital registration and insurance claims data to construct the GBD model, numerous locations and several of the time periods examined lack primary data, particularly in low- and middle-income countries (LMICs). This led to lower certainty and generalizability of our findings, highlighting the importance of improving data collection in LMICs to ensure that the estimates from the modeling process are grounded in more primary data. Second, although evidence suggests an association between air pollution and ILD and occupational risk and pneumoconiosis, the GBD currently links occupational risk factors only to specific subtypes—namely asbestosis, silicosis and pneumoconiosis due to particulates—whereas other potential environmental and occupational risk–outcome pairs remain unincorporated[36]. This gap limits our understanding of how broader environmental factors contribute to these diseases[37]. Meanwhile, this lag in risk factor integration may reflect the rigorous selection criteria of the GBD framework[38], which requires sufficient evidence of causation for each risk-outcome pair, as determined by the Bradford Hill criteria. These criteria also mandate the availability of risk exposure data and ensure the relevance of the risk for modification and policy implementation[39]. As such, emerging exposures, such as vaping and cannabis use, remain excluded due to the lack of standardized global data or insufficient evidence to satisfy these criteria[40]. Expanding the list of established risk factors is a strong motivation for the GBD, and more risk factors are expected to be included in future GBD iterations[38]. Third, the criteria used to diagnose chronic respiratory diseases and the methods by which spirometry results are interpreted varied across data sources and regions, which may affect the accuracy of our estimates. Although the GBD 2023 framework implemented adjustments for datasets that did not adhere to the reference definition, residual bias may still persist due to the underutilization of spirometry in specific settings, as well as evolving diagnostic practices and coding systems (for example, transitioning from ICD-9 to ICD-10). Additionally, the broader availability of advanced imaging in regions such as North America may lead to earlier or more frequent detection of chronic respiratory diseases (for example, ILD), affecting the comparability of estimates across different settings. Fourth, despite the association between some chronic respiratory diseases and pulmonary hypertension, we excluded pulmonary hypertension from the chronic respiratory disease category. Pulmonary hypertension is primarily classified as a cardiovascular disease, especially in the context of heart failure, and was categorized in the GBD framework.

Finally, our findings regarding the impact of the COVID-19 pandemic on chronic respiratory disease should be interpreted with caution for several reasons. The complex relationship between COVID-19 and chronic respiratory disease, such as COVID-19 may be associated with long-term respiratory complications and increases the risk of severe infection in individuals with preexisting respiratory conditions, may complicate interpretation. Additionally, deaths from chronic respiratory diseases may be underreported, as individuals with these conditions who were infected with SARS-CoV-2—particularly older adults—might have been classified as COVID-19-related fatalities. These limitations highlight the importance of cautious interpretation of post-pandemic trends rather than suggesting changes to the GBD modeling framework.

In conclusion, although the overall burden of chronic respiratory diseases has decreased over time, the number of people affected by chronic respiratory diseases still remains substantial, with variations depending on subcategories and regions. Despite the lower prevalence in limited-resource settings, the DALY was relatively high in these regions, suggesting that lower socioeconomic status influences disease prevention and management. During the COVID-19 pandemic, age-standardized incidence rates for chronic respiratory disease have remained relatively stable, whereas age-standardized death rates, which had been declining steadily in the pre-pandemic

period, showed a reversal and began to rise. The disease burden estimates across pre-COVID-19 and pandemic periods provided by this study may help guide healthcare policymaking and prioritization to reduce premature mortality from NCDs through prevention and treatment, in line with the United Nations' SDG 3.4.

Online content

Any methods, additional references, Nature Portfolio reporting summaries, source data, extended data, supplementary information, acknowledgements, peer review information; details of author contributions and competing interests; and statements of data and code availability are available at https://doi.org/10.1038/s41591-025-04077-9.

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Methods

Overview

The GBD 2023 provides an updated assessment of the burden of 375 diseases and injuries and 88 risk factors in 204 countries and territories between 1990 and 2023[4]. As part of the GBD Collaborative Network, this study evaluates the chronic respiratory disease estimates of GBD 2023 by age, sex, location, year, and SDI and presents the potential policy impact of the estimates. This study followed the guidelines for accurate and transparent health estimate reporting (GATHER) statements (Supplementary Table 2). Detailed descriptions of the methodology and statistical codes for the GBD estimation can be found elsewhere[4,38]. Below, we provide a comprehensive summary of the relevant methods, which are based on the standardized framework outlined in the official publication of GBD 2023.

Case definition and input data

For chronic respiratory diseases, GBD 2023 produced estimates for four categories: COPD, asthma, pneumoconiosis, and ILD and pulmonary sarcoidosis[2,3]. COPD is defined in accordance with the Global Initiative for Chronic Obstructive Lung Disease (GOLD) criteria[4,36]. Asthma is a chronic respiratory condition induced by allergic reactions or hypersensitivity that results in bronchial spasms and breathing difficulties. Pneumoconiosis is a chronic lung disease that results from lung scarring and interstitial damage caused by prolonged exposure to dust and other contaminants; GBD 2023 estimated pneumoconiosis by incorporating diagnoses of specific conditions such as silicosis, asbestosis, silicosis, coal workers' pneumoconiosis, and other related diseases. ILD and pulmonary sarcoidosis encompass various chronic respiratory conditions that affect lung function and oxygen absorption owing to scarring and/or inflammation. The definition provided by the American Thoracic Society for ILD is the gold standard. In addition to the chronic respiratory disease discussed earlier, there are other chronic respiratory diseases and their associated complications.

For data processing and quality control, outlier criteria were applied to ensure reliability across data sources. Data points were excluded if they (1) were implausibly high or low, (2) clearly conflicted with established age or temporal patterns, or (3) substantially conflicted with other data sources from the same or similar locations, as determined by the SDI. Further details, including International Classification of Diseases (ICD) codes for each disease, are provided in the Supplementary Table 3 [4].

Classification of geographic locations

GBD produced estimates for territories of 204 countries, grouped into 21 regions and 7 super regions. The seven super-regions are Central Europe, Eastern Europe, and Central Asia; high-income; Latin America and the Caribbean; North Africa and the Middle East; South Asia; Southeast Asia, East Asia, and Oceania; and Sub-Saharan Africa. The twenty-one GBD regions include East Asia, Oceania, Southeast Asia, Central Asia, Central Europe, Eastern Europe, Australasia, High-income Asia Pacific, High-income North America, Southern Latin America, Western Europe, Andean Latin America, Caribbean, Central Latin America, Tropical Latin America, North Africa and the Middle East, South Asia, Central sub-Saharan Africa, Eastern sub-Saharan Africa, Southern sub-Saharan Africa, and Western sub-Saharan Africa. Countries corresponding to each GBD super region and region are shown in the Supplementary Table 4.

Non-fatal estimates

GBD 2023 used population-representative surveys, small-scale prevalence studies identified through systematic literature reviews, and hospital-based data sources to derive the non-fatal estimates of chronic respiratory diseases[39]. To integrate these diverse data sources and generate consistent estimates across sex, location, year, and age groups, DisMod-MR 2.1 was employed. This Bayesian meta-regression tool integrates epidemiological information from various sources using a differential equation framework, ensuring internal consistency among key metrics such as prevalence, incidence, remission, and mortality[39].

The modeling process for GBD 2023 incorporated adjustments for disability weights and the complications of sequelae, enabling more refined and comprehensive estimates for chronic respiratory diseases[2,3]. Specifically, non-fatal estimates for COPD were determined by integrating spirometry-based studies and data reflecting severity distributions and applying correction factors for case definitions based on bronchodilator use, as well as incorporating prior estimates of excess mortality informed by healthcare access and quality indices through MR-BRT models. Asthma estimates were refined by incorporating additional data from 81 new geographies, thereby enhancing bias adjustment for heterogeneous case definitions. Additionally, pneumoconiosis estimates were improved by including occupational exposure covariates, and ILD and pulmonary sarcoidosis estimates were enhanced through the application of MEPS-derived severity distributions and differentiation between narrow and broad case definitions based on ICD coding[4]. Moreover, DisMod-MR 2.1 generated estimates across five levels of the GBD geographic hierarchy and produces estimates for locations lacking raw epidemiological data[41]. In GBD 2023, model inputs were further refined by replacing internal correction factors with externally applied adjustments through MR-BRT, and by increasing the minimum prior uncertainty (coefficient of variation raised from 0.4 to 0.8) to better capture true variance across heterogeneous data sources.

Mortality estimates

The modeling framework for mortality estimation is described briefly below with further detail provided in the summary cause of death publication for GBD 2023[36]. The cause-of-death ensemble model (CODEm) was used to simulate the majority of cause-of-death estimates for illnesses and injuries. CODEm tests covariate combinations based on out-of-sample performance metrics and integrates them into an ensemble to estimate mortality by cause, location, age, sex, and year[42]. To address heterogeneity in data availability and quality, CODEm was run separately for each sex, incorporating covariates related to health system performance, data completeness, and socioeconomic development to account for differences across locations, thereby reducing the propagation of uncertainty[39]. This methodology adheres to ICD-9 and 10, attributing each mortality to the underlying cause and initiating the chain of events leading to mortality[2,3]. Chronic respiratory disease mortality estimates are post-processed through the CoDCorrect algorithm, which scales these estimates to align with the all-cause mortality envelope to ensure internal consistency. In GBD 2023, improved noise-reduction algorithms and expanded outlier-detection procedures were applied to enhance data quality, including more rigorous filtering based on implausible age patterns, abrupt year-on-year fluctuations, and inter-source inconsistencies[36].

The mortality estimates are derived primarily from vital registration and surveillance data, with verbal autopsy information being integrated into the overall disease model. Covariate inclusion was optimized based on the predictive validity of each model, and the level and expected direction of effect for each covariate were assessed systematically across causes and age-sex groups[36]. Specific considerations for each disease are as follows: for COPD, covariates such as cumulative smoking, indoor and outdoor air pollution, and altitude are incorporated, and verbal autopsy were refined using updated redistribution algorithms before integration, and high-resolution exposure maps were applied to enhance spatial granularity; for asthma, sex-specific models account for bias adjustments related to case definitions and include relevant covariates such as cumulative smoking and healthcare access and quality index, which were updated using new MR-BRT-based exposure transformations; for pneumoconiosis, separate models are developed for the overall condition and for individual subtypes

(for example, silicosis, asbestosis, and coal worker's pneumoconiosis), incorporating additional covariates that reflect occupational exposure, including per capita asbestos consumption and coal production, were incorporated at higher resolution; and for ILD and pulmonary sarcoidosis, sex-specific models integrate relevant covariates—including smoking prevalence, cumulative smoking, indoor and outdoor air pollution, and altitude—while incorporating MR-BRT-based crosswalk adjustments to harmonize narrow and broad case definitions derived from ICD coding, with final estimates aligned to the all-cause mortality envelope using CoDCorrect and refined through enhanced noise filtering and verbal autopsy redistribution procedures[36].

DALY estimates

DALYs are the primary measures of total health loss due to fatal and non-fatal disease burdens, allowing comparisons across diseases and injuries[39]. To estimate DALYs for GBD 2023, years of life lost (YLLs) were combined with years lived with disability (YLDs) across age-sex-location groups for each year considered[4]. YLLs were calculated by multiplying the global standard life expectancy at the time of death by the number of deaths per 100,000 population. To estimate YLDs, the combined frequency and duration of an illness or injury are weighted by a disability weight, a measure of disease severity that ranges from 0 (full health) to 1 (fatal severity). Consequently, DALYs, calculated as the total of YLLs and YLDs, quantify the equivalent of one lost year of healthy life per DALY for a population. To account for uncertainty, 250 draws were generated by summing the matched draws of YLLs and YLDs (for example, the first draw of each, the second draw of each, and so on), and 95% UIs were defined as the 2.5th and 97.5th values from the ordered distribution of these draws[43].

Risk factor analysis

The GBD 2023 Comparative Risk Assessment framework was used to quantify the attributable burden of chronic respiratory diseases[8,38,42]. GBD risk factors are categorized into a four-level hierarchy, from broad categories (behavioral, environmental/occupational, and metabolic) at level 1 to specific categories (for example, $PM_{2.5}$ pollution) at level 4 (refs. 4,38).

Theoretical minimum risk exposure level (TMREL) is defined in the GBD study as the ideal population exposure level with the lowest risk and served as the benchmark for calculating attributable burden. In GBD 2023, TMRELs were specified as uniform distributions to account for scientific uncertainty, and mediation analyses were more extensively integrated to improve the estimation of overlapping risk pathways. The modeling process included the following steps: (1) estimating the relative risk (RR) for potential risk-outcome pairs through a comprehensive analysis of previously published studies, (2) estimating exposure levels using population-based datasets and modeled estimates for missing data, (3) defining TMREL based on epidemiological evidence, (4) calculating the population attributable fraction (PAF) using exposure data and RR, considering latency periods for risk factors with delayed effects on health outcomes, (5) adjusting disease prevalence or mortality data by incorporating RR, and applying the PAF to estimate the attributable burden, and (6) combining multiple risk factors using a multiplicative PAF approach while incorporating mediation analysis to account for overlapping pathways and interactions. To address data heterogeneity and uncertainty, the MR-BRT model was applied, providing refined estimates for risk-outcome relationships[38]. The selection of risk-outcome pairs was established based on the presence of strong or probable evidence, evaluated according to the methods and criteria set by the World Cancer Research Fund[4], availability of exposure data, feasibility of behavioral changes, and public health relevance.

For each disease, risk factors for chronic respiratory diseases were estimated differently. For COPD, eight factors were identified: ambient ozone pollution; $PM_{2.5}$ pollution; smoking; secondhand smoke; occupational exposure to particulate matter, gases, fumes; household air pollution from solid fuels; and high and low temperatures. Six factors were identified for asthma: high BMI, smoking, occupational asthma, secondhand smoke, childhood sexual abuse and nitrogen dioxide (NO_2) pollution. Pneumoconiosis is associated with three factors: occupational exposure to asbestos, silica, and particulate matter, gases, and fumes. No risk factors for ILD or pulmonary sarcoidosis were identified[4,38].

For COPD, ambient ozone pollution was quantified using satellite remote sensing data (for example, from European Centre for Medium-Range Weather Forecasts Reanalysis version 5 (ERA5)) combined with ground-based measurements, whereas $PM_{2.5}$ pollution estimates were derived from a fusion of ground monitor observations, reanalysis products and chemical transport model simulations, with updated inputs from satellite-based land-use regression models and enhanced resolution rasters. Smoking and secondhand smoke exposures were assessed through nationally representative surveys and vital registration data, with adjustments for self-report bias and temporal trends implemented using MR-BRT methods. Occupational exposures to particulate matter, gases, and fumes were characterized using International Labour Organization data and industry-specific exposure assessments, and household air pollution from solid fuels was estimated based on data from sources like the WHO Household Energy Database, Demographic and Health Surveys, and Living Standards Measurement Surveys. Exposure to high and low ambient temperatures was determined using ERA5 reanalysis data in combination with high-resolution population data from WorldPop to capture deviations from the TMREL, with additional uncertainty modeling applied to temperature-attributable burden estimation. For asthma, BMI was estimated using a global survey series and systematic literature reviews, whereas NO_2 pollution exposure was generated by integrating satellite-based measurements with ground monitoring data and chemical transport model outputs; GBD 2023 incorporated updated global NO_2 exposure rasters based on land-use regression and chemical transport models. Secondhand smoke and childhood sexual abuse were newly classified as risk factors for asthma in the GBD 2023 iteration, reflecting the expanding epidemiological evidence on psychosocial and environmental determinants of disease burden. For pneumoconiosis, the risk was primarily attributed to occupational exposures to asbestos, silica, and other particulate matter, gases, and fumes—derived from mesothelioma mortality data, CARcinogen EXposure databases, and International Labour Organization occupational exposure information[38].

Disease burden in pre-COVID-19 and pandemic periods

To investigate temporal trends before (2010–2019) and during (2020–2023) the pandemic, we calculated the AAPC for each disease[44,45]. AAPC is a summary measure derived from the APC, which reflects the year-over-year rate of change in incidence or mortality, averaged over a specified time[44,46]. The APC was estimated using a log-linear regression model, and AAPC was calculated as the weighted average of APCs over the specified time intervals, with weights proportional to the number of years in each interval:

$$\mathrm{AAPC} = \frac{\sum(w_i \times \mathrm{APC}_i)}{\sum w_i}$$

where AAPC_i is the APC for each interval i, and w_i represents the number of years in that interval. This approach ensures a more stable estimate of temporal trends over multiple time periods.

SDI

The SDI is a composite measure of the social and economic factors that influence health outcomes in each region[47]. In essence, the SDI is calculated as the geometric mean of three indices: TFU25 (total fertility rate

under age 25), EDU15+ (average educational attainment of individuals aged 15 and older) and LDI (delayed distributive income per capita). Each of these indices has a range of 0 to 1. Based on its value, the SDI is divided into five categories: high SDI, high-middle SDI, middle SDI, low-middle SDI and low SDI[48].

Data presentation

The GBD world population age standard was applied to calculate age-standardized rates for prevalence, death and DALY of chronic respiratory diseases. To assess changes over time, we calculated the percentage change in the rates between the start and end of the time period, with the change expressed as the difference between the new and old rates divided by the old rate. All rates presented are age-standardized unless specifically indicated as age-specific rates. All modeling was conducted for 500 draws[4,38], and the UI was calculated using the 2.5th and 97.5th percentiles of the draws. Analyses were performed using Python (version 3.10.4; Python Software Foundation) and R (version 4.2.1; R Foundation).

Ethics and inclusion statement

The GBD framework ensures that estimates are derived from diverse data sources, including population-based registries and national health surveys, covering 204 countries and territories. The research team included collaborators from various regions who contributed expertise in epidemiology, disease modeling and health policy. All authors agreed upon roles and responsibilities at the outset of the study.

Reporting summary

Further information on research design is available in the Nature Portfolio Reporting Summary linked to this article.

Data availability

The findings from this study were produced using data available in public online repositories or in the published literature, as well as data that are publicly available from the data provider under certain conditions. Details on data sources can be found on the GHDx website, including information about the data provider and links to where the data can be accessed (where available). Citations and metadata for all input sources used in this analysis are available for download at https://ghdx.healthdata.org/gbd-2023/sources. Most GBD data can be accessed directly upon visiting the GHDx website, and some datasets may require agreement to a data use policy before download. Access is typically granted immediately upon completion of these steps.

Code availability

Our study follows the Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER; Supplementary Table 4). All code used for this analysis is publicly available online at https://github.com/CenterForDH/Chronic-respiratory-diseases.git.

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Author contributions

J.O., S. Kim, Y. Yim, M.S.K., S.I.H., J.I.S. and D.K.Y. conceptualized and designed the study. These authors also developed the methodology and acquired the data. J.O., S. Kim, Y. Yim, M.S.K., S.I.H., J.I.S. and D.K.Y. conducted the statistical analysis and curated the data. S.I.H., J.I.S. and D.K.Y. validated the findings, interpreted the data and created the visualizations. They also managed the estimation or publications process. J.O., S. Kim and Y. Yim prepared the original draft. All authors reviewed and edited the paper and provided critical revisions. S.I.H., J.I.S. and D.K.Y. supervised the work and oversaw project administration. These same authors secured the funding. Contributions by the GBD 2023 Global Chronic Respiratory Disease and COVID Collaborators are described in the Supplementary Information.

Competing interests

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Additional information

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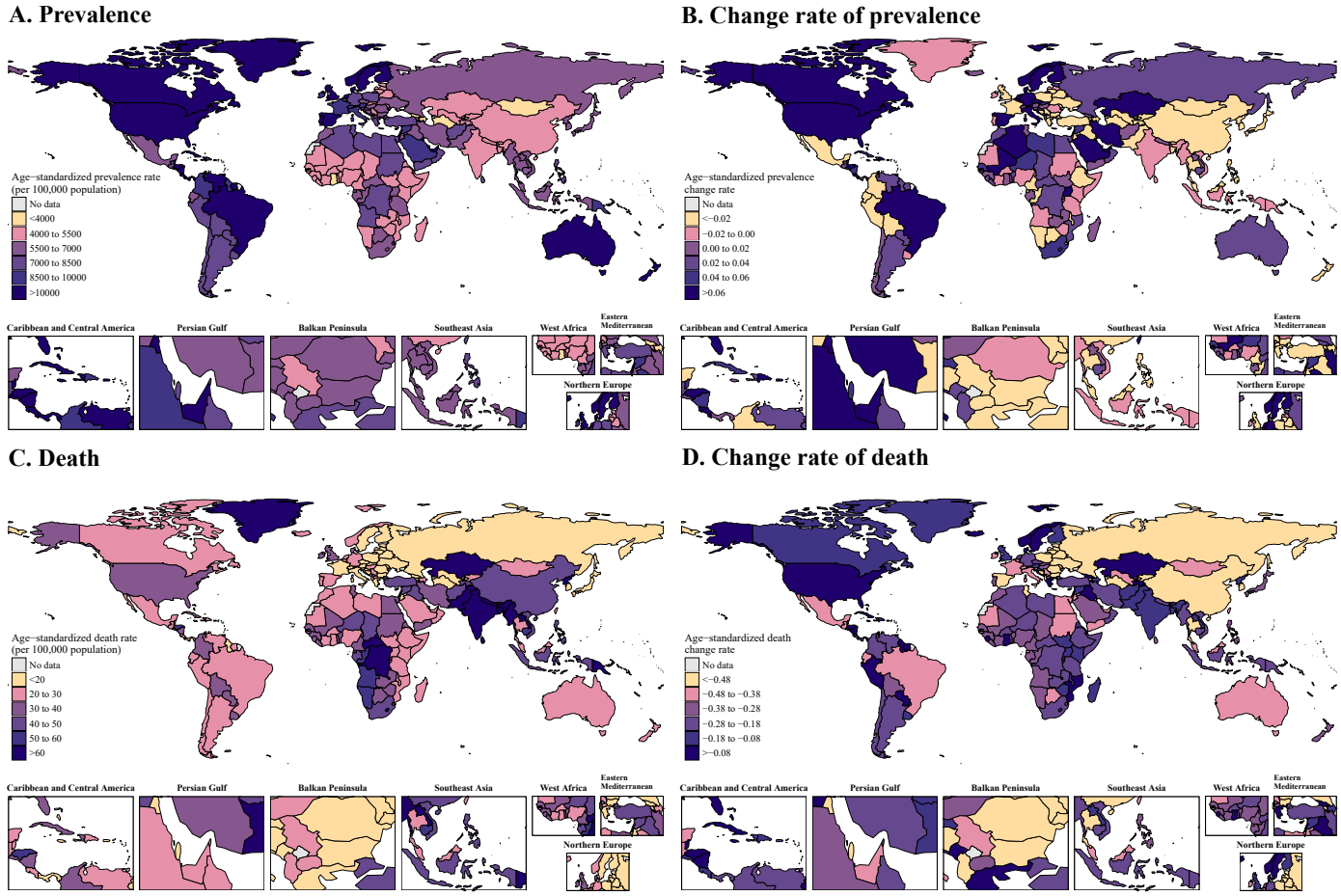

Extended Data Fig. 1 | World map of age-standardized prevalence (A) and death rates (C) of chronic respiratory disease in 2023 and percentage change (B, D) from 1990 to 2023. The figure displays the worldwide age-standardized prevalence rate (**A**) and death rate (per 100,000 population) (**C**) of chronic respiratory diseases in 2023, alongside the respective change rates in prevalence (**B**) and death (**D**) from 1990 to 2023. The color gradient, ranging from dark purple (high value) to pale yellow (low value), indicates the magnitude of each metric. The small insets beneath the main map provide magnified views of the Caribbean and Central America, the Persian Gulf, the Balkan Peninsula, Southeast Asia, West Africa, the Eastern Mediterranean, and Northern Europe.

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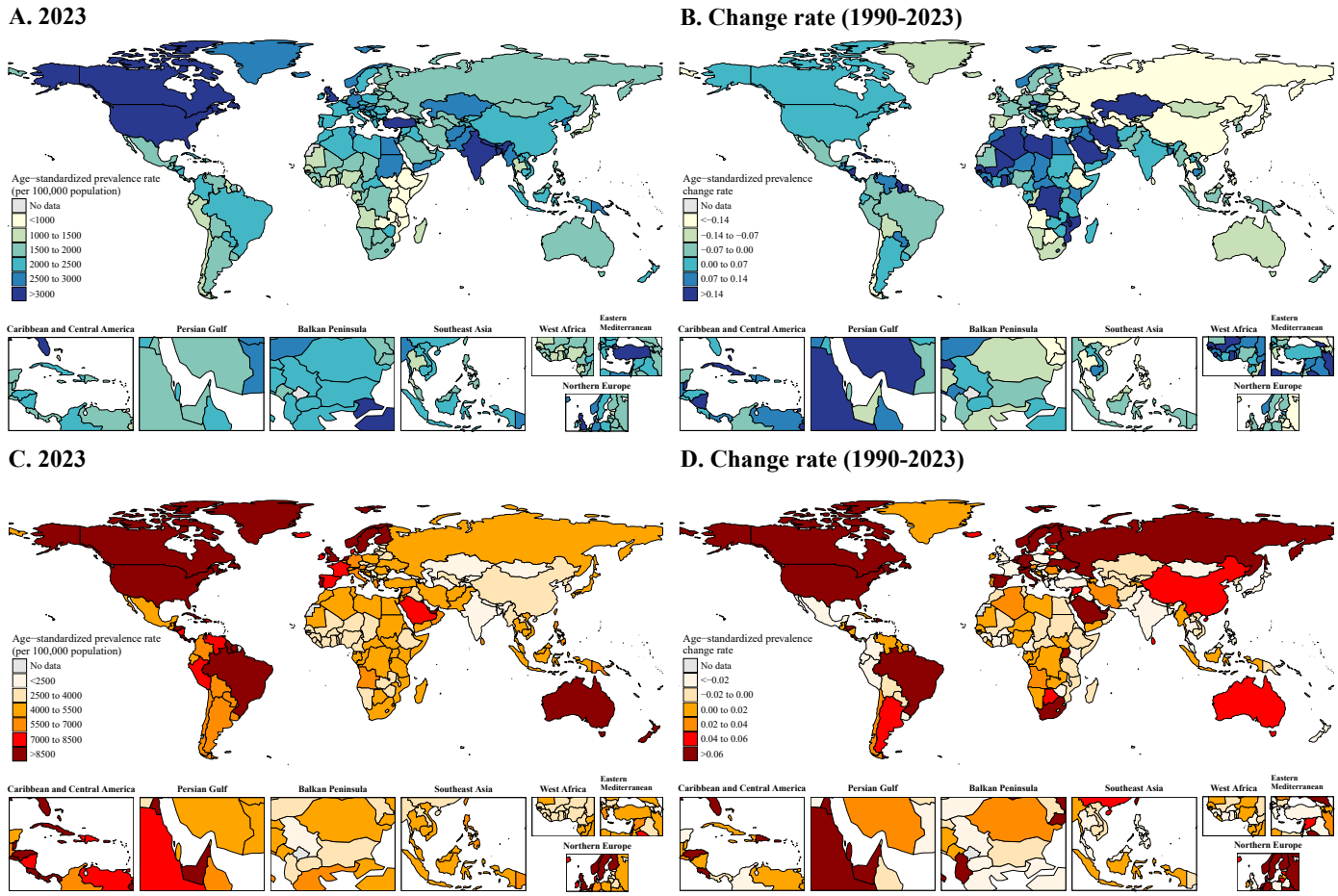

Extended Data Fig. 2 | World map of age-standardized prevalence rates for COPD (A, B) and asthma (C, D) in 2023 and percentage change from 1990 to 2023. Abbreviation: COPD, chronic obstructive pulmonary disease. The figure displays the worldwide age-standardized prevalence rate (per 100,000 population) of COPD (**A**) and asthma (**C**) in 2023, alongside the respective change rates of COPD (**B**) and asthma (**D**) in prevalence from 1990 to 2023. The color gradient, ranging from dark blue or red (high value) to pale yellow (low value), indicates the magnitude of each metric. The small insets beneath the main map provide magnified views of the Caribbean and Central America, the Persian Gulf, the Balkan Peninsula, Southeast Asia, West Africa, the Eastern Mediterranean, and Northern Europe.

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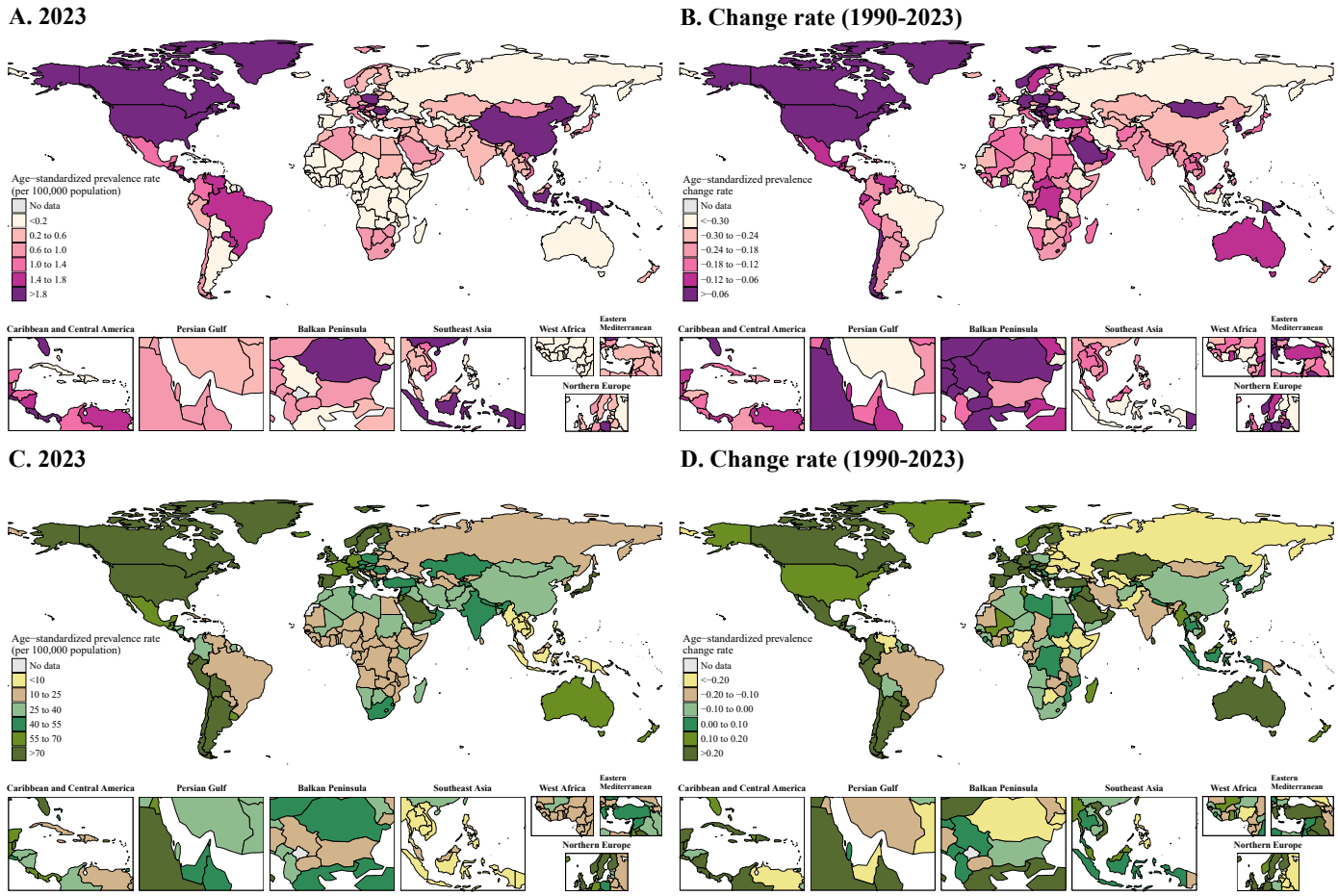

Extended Data Fig. 3 | World map of age-standardized prevalence rates for pneumoconiosis (A, B) and interstitial lung diseases and pulmonary sarcoidosis (C, D) in 2023 and percentage change from 1990 to 2023. The figure displays the worldwide age-standardized prevalence rate (per 100,000 population) of pneumoconiosis (**A**) and interstitial lung diseases and pulmonary sarcoidosis (**C**) in 2023, alongside the respective change rates of pneumoconiosis (**B**) and interstitial lung diseases and pulmonary sarcoidosis (**D**) in prevalence from 1990 to 2023. The color gradient, ranging from dark purple or green (high value) to pale yellow (low value), indicates the magnitude of each metric. The small insets beneath the main map provide magnified views of the Caribbean and Central America, the Persian Gulf, the Balkan Peninsula, Southeast Asia, West Africa, the Eastern Mediterranean, and Northern Europe.

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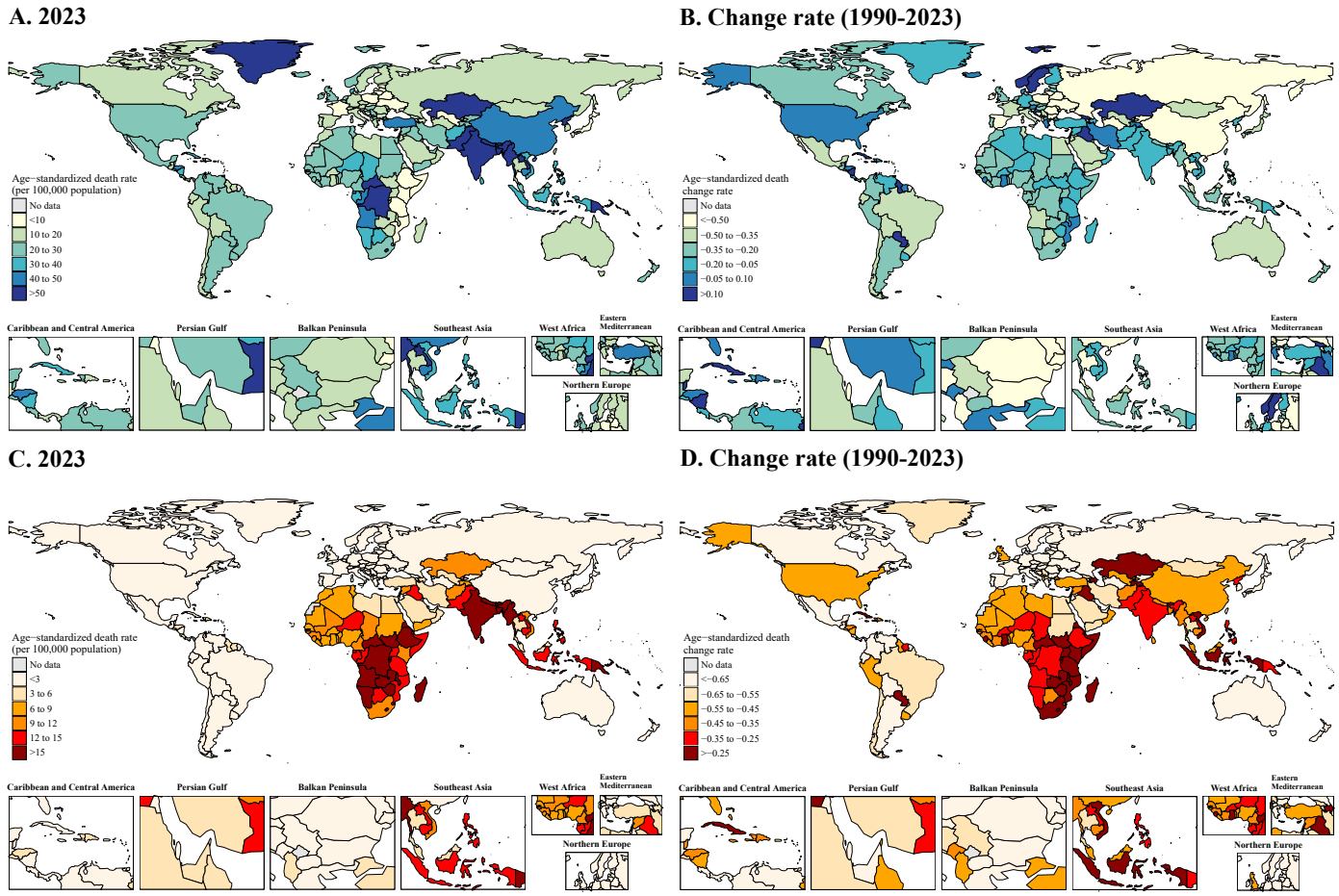

Extended Data Fig. 4 | World map of age-standardized death rates for COPD (A, B) and asthma (C, D) in 2023 and percentage change from 1990 to 2023. Abbreviation: COPD, chronic obstructive pulmonary disease. The figure displays the worldwide age-standardized death rate (per 100,000 population) of COPD (**A**) and asthma (**C**) in 2023, alongside the respective change rates of COPD (**B**) and asthma (**D**) in prevalence from 1990 to 2023. The color gradient, ranging from dark blue or red (high value) to pale yellow (low value), indicates the magnitude of each metric. The small insets beneath the main map provide magnified views of the Caribbean and Central America, the Persian Gulf, the Balkan Peninsula, Southeast Asia, West Africa, the Eastern Mediterranean, and Northern Europe.

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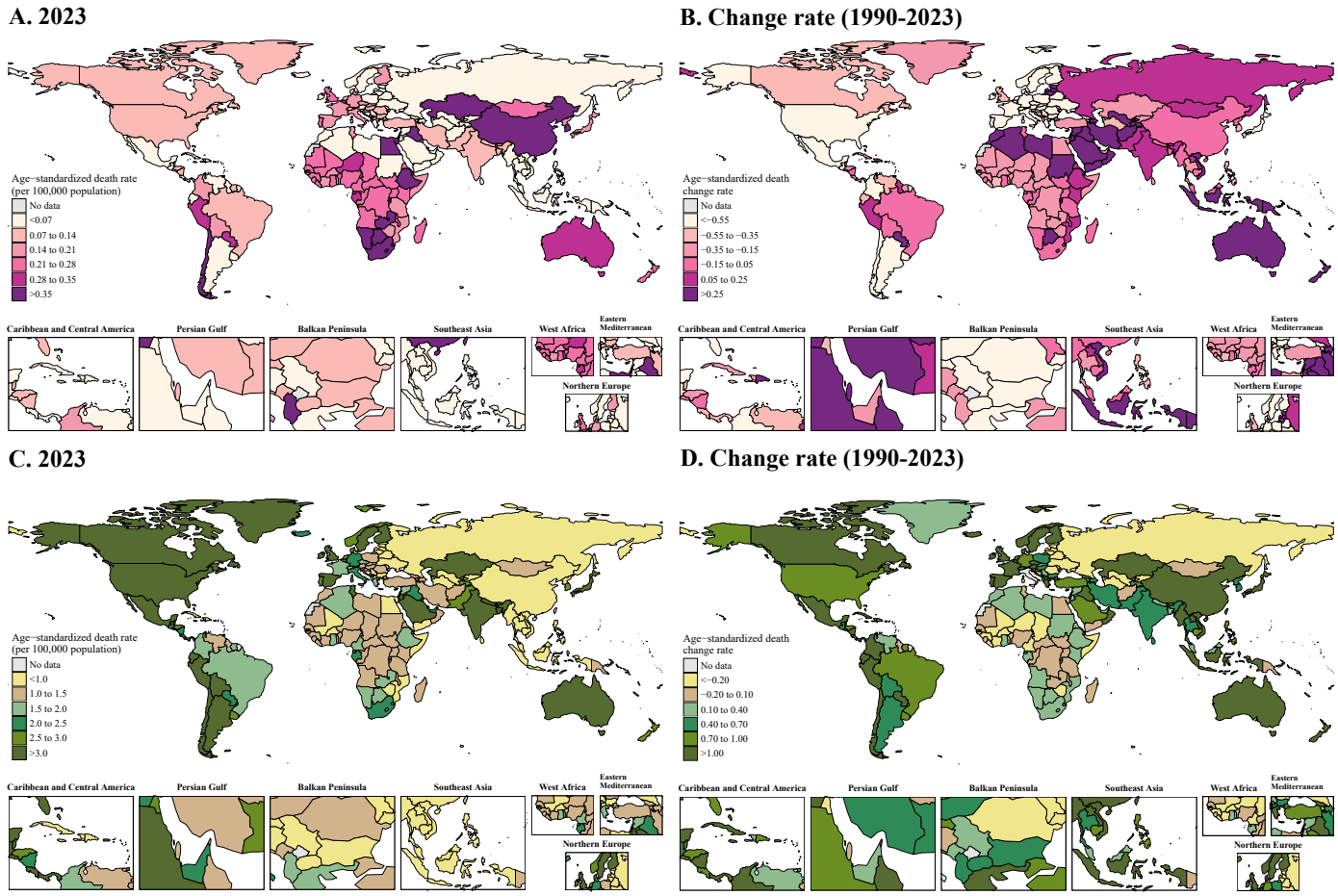

Extended Data Fig. 5 | World map of age-standardized death rates for pneumoconiosis (A, B) and interstitial lung diseases and pulmonary sarcoidosis (C, D) in 2023 and percentage change from 1990 to 2023. The figure displays the worldwide age-standardized death rate (per 100,000 population) of pneumoconiosis (**A**) and interstitial lung diseases and pulmonary sarcoidosis (**C**) in 2023, alongside the respective change rates of pneumoconiosis (**B**) and interstitial lung diseases and pulmonary sarcoidosis (**D**) in prevalence from 1990 to 2023. The color gradient, ranging from dark purple or green (high value) to pale yellow (low value), indicates the magnitude of each metric. The small insets beneath the main map provide magnified views of the Caribbean and Central America, the Persian Gulf, the Balkan Peninsula, Southeast Asia, West Africa, the Eastern Mediterranean, and Northern Europe.

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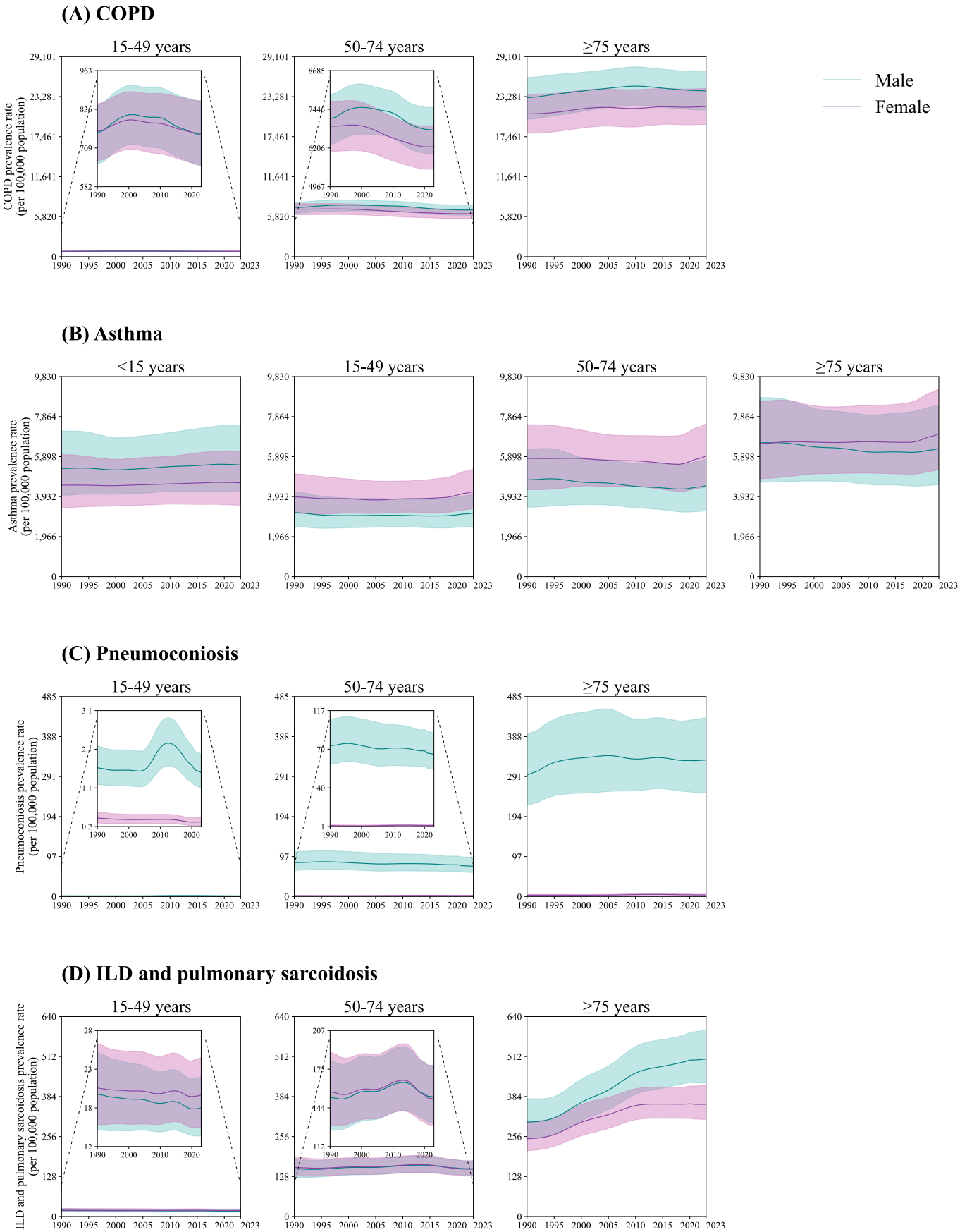

Extended Data Fig. 6 | See next page for caption.

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Extended Data Fig. 6 | Global age-sex-specific COPD (A), asthma (B), pneumoconiosis (C), ILD and pulmonary sarcoidosis (D) prevalence rates, 1990–2023. Abbreviation: COPD, chronic obstructive pulmonary disease; ILD, interstitial lung disease. The figure presents the 1990–2023 global age- and sex-specific prevalence rate trends for COPD (**A**), asthma (**B**), pneumoconiosis (**C**), and ILD and pulmonary sarcoidosis (**D**). Blue indicates male, and pink indicates female. The bold line represents the mean prevalence rate (derived from the GBD 2023 draws), and the lighter shading denotes the 95% uncertainty interval (UI). For age groups whose trends are not clearly visible due to y-axis scaling, inset figures are provided. These data are population-level estimates (no separate biological or technical replicates), and the unit of study is the entire population in each region-year. No control group was used, as this is an observational, population-based analysis.

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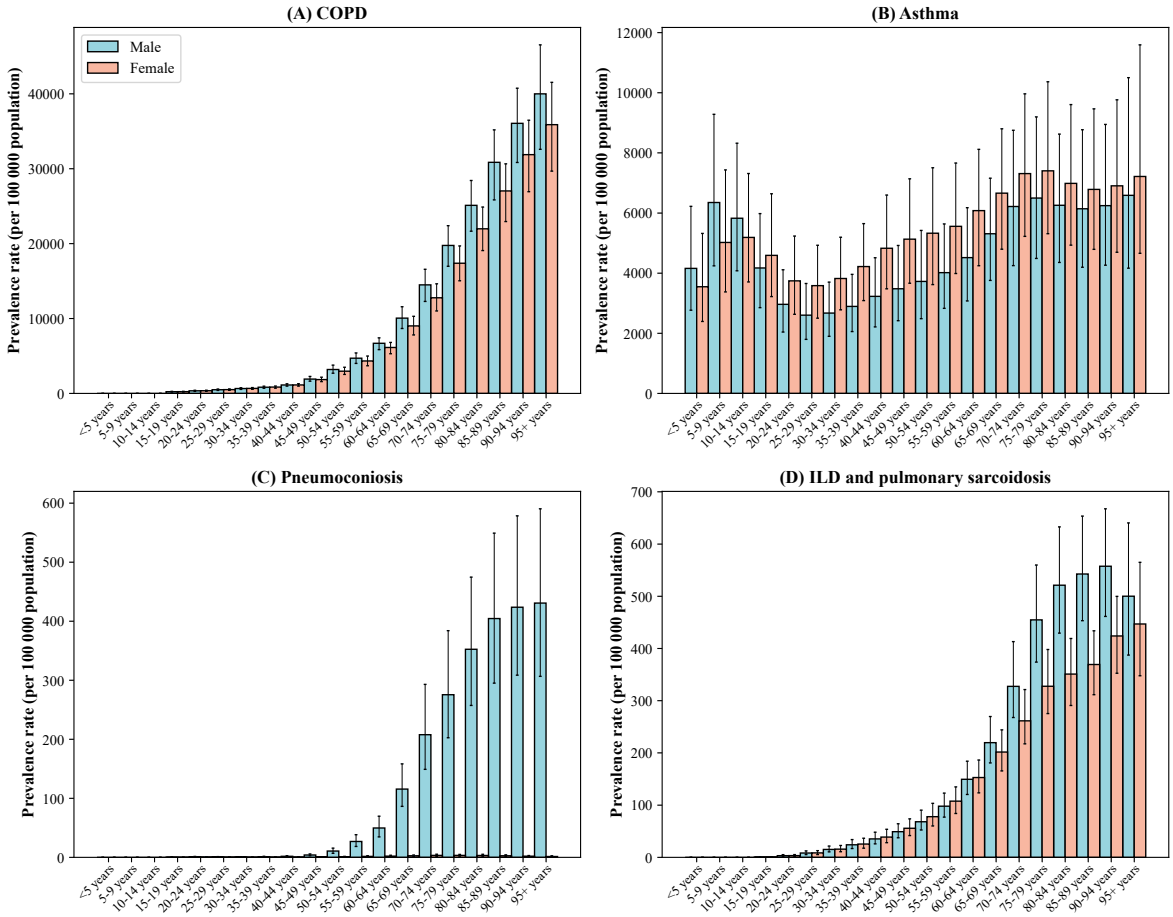

Extended Data Fig. 7 | Global age-sex distribution of COPD (A), asthma (B), pneumoconiosis (C), and interstitial lung diseases (ILD) and pulmonary sarcoidosis (D) prevalence rates in 2023. Abbreviation: COPD, chronic obstructive pulmonary disease; ILD, interstitial lung disease. The figure presents the 2023 global age- and sex-specific prevalence rates (per 100,000 population) of COPD (**A**), asthma (**B**), pneumoconiosis (**C**), and interstitial lung diseases and pulmonary sarcoidosis (**D**). Each bar represents the mean prevalence rate derived from the GBD 2023 draws for each region, with the thin black lines indicating the 95% uncertainty intervals (UI). Blue bars represent males, pink bars represent females. These estimates are population-level data (no separate biological or technical replicates), and the unit of study is the entire population in each region. No control group was used, as this is an observational, population-based analysis.

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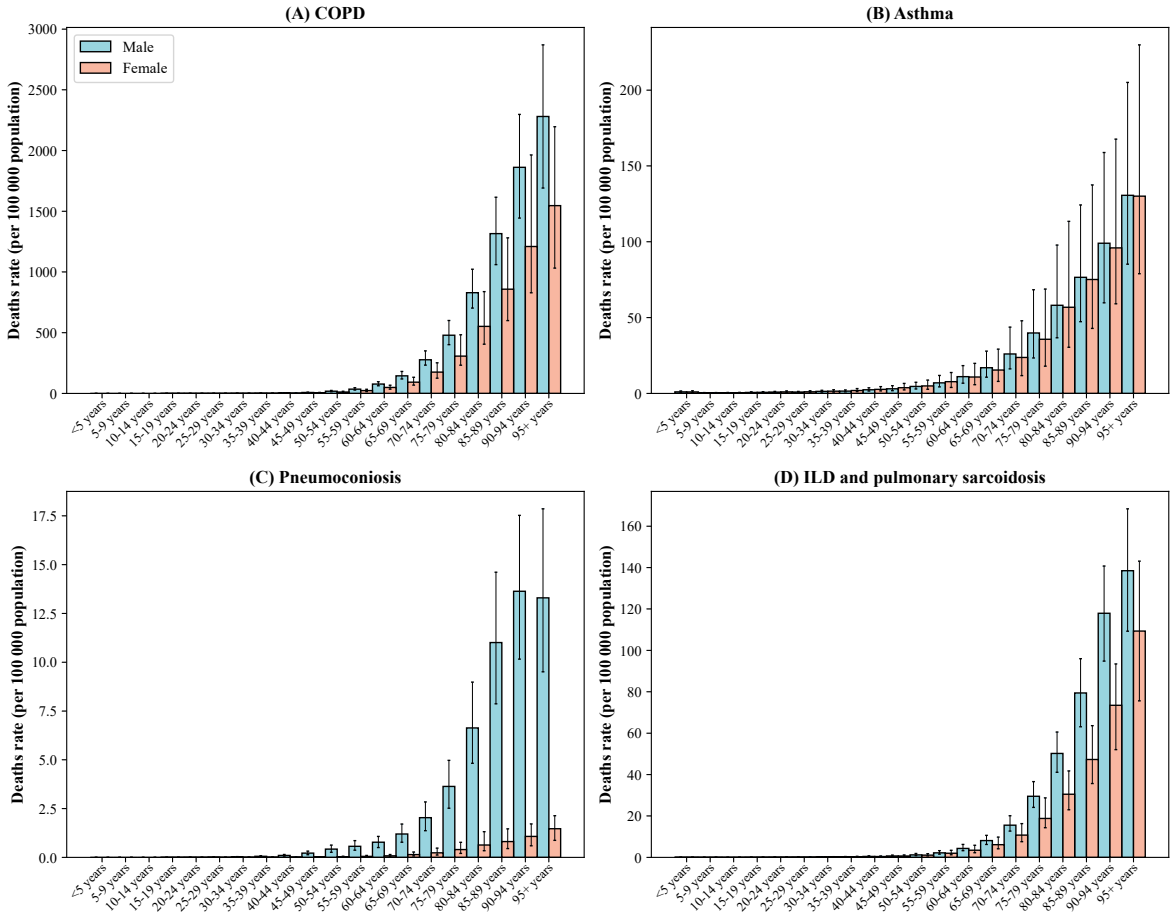

Extended Data Fig. 8 | Global age-sex distribution of COPD (A), asthma (B), pneumoconiosis (C), and interstitial lung diseases (ILD) and pulmonary sarcoidosis (D) death rates in 2023. Abbreviation: COPD, chronic obstructive pulmonary disease; ILD, interstitial lung diseases. The figure presents the 2023 global age- and sex-specific death rates (per 100,000 population) of COPD (**A**), asthma (**B**), pneumoconiosis (**C**), and interstitial lung diseases and pulmonary sarcoidosis (**D**). Each bar represents the mean death rate derived from the GBD 2023 draws for each region, with the thin black lines indicating the 95% uncertainty intervals (UI). Blue bars represent males, and pink bars represent females. These estimates are population-level data (no separate biological or technical replicates), and the unit of study is the entire population in each region. No control group was used, as this is an observational, population-based analysis.

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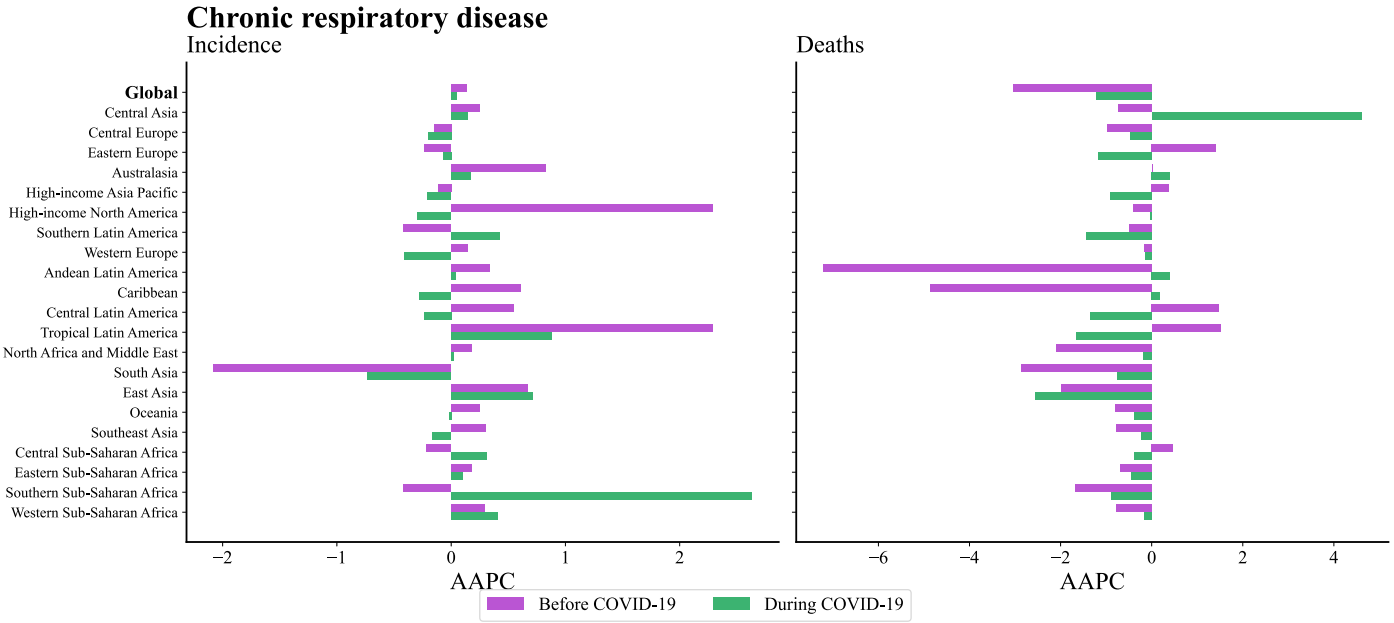

Extended Data Fig. 9 | AAPC of age-standardized incidence and death rates for chronic respiratory diseases by GBD region during the pre-COVID-19 (2010–2019) and the pandemic period (2020–2023). The figure presents the average annual percentage changes in age-standardized incidence and death rates (per 100,000 population) of CRDs by GBD region for the pre-COVID-19 period (2010–2019) and the pandemic period (2020–2023). Purple bars represent the pre-pandemic period (2010–2019), and green bars represent the pandemic period (2020–2023).

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Policy information about availability of computer code

Data collection	No software was used for data collection for this analysis.
Data analysis	The analyses were performed using Python (version 3.11.4; Python Software Foundation, Wilmington, DE, USA) and R (version 4.3.2; R Foundation, Vienna, Austria). All code used for this analysis is publicly available online at https://github.com/CenterForDH/Chronic-respiratory-diseases.git.

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to where the data can be accessed (where available). Citations and metadata for all input sources used in this analysis are available for download at https://ghdx.healthdata.org/gbd-2023/sources. Most GBD data can be accessed directly upon visiting the GHDx website, and some datasets may require agreement to a data use policy before download. Access is typically granted immediately upon completion of these steps.

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Policy information about studies with human participants or human data. See also policy information about sex, gender (identity/presentation), and sexual orientation and race, ethnicity and racism.

Reporting on sex and gender	No primary data collection was carried out for this analysis, so the study does not involve human research participants. As stated in the methods overview, estimates were stratified by sex.
Reporting on race, ethnicity, or other socially relevant groupings	Not applicable.
Population characteristics	Not applicable.
Recruitment	Not applicable.
Ethics oversight	This study was approved by the University of Washington IRB Committee.

Note that full information on the approval of the study protocol must also be provided in the manuscript.

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All studies must disclose on these points even when the disclosure is negative.

Sample size	Sample size was defined as the population of every location used in our analysis. State-, country-, region-, super-region, and global-level populations are estimated as part of the Global Burden of Disease Study 2021. Detailed methods are described in https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(24)00757-8/fulltext.
Data exclusions	We carefully evaluated all data sources for inclusion in our study. Sources were excluded if they lacked necessary survey weight factors or crucial demographic information such as sex or age variables. Additionally, we omitted data deemed unreliable, based on assessments by survey administrators or through our own detailed examination. This careful selection process ensured the quality and completeness of the information used in our analysis.
Replication	This is a systematic analysis of existing studies with many years of cohort and other existing data. Reproducibility of this work can be achievable with access to the data and the publicly available code at https://ghdx.healthdata.org/gbd-2021/code.
Randomization	Randomization was not relevant to this study. This analysis is a meta-analysis of existing studies and thus, there were no experimental groups.
Blinding	Blinding was not relevant to this study, as it was an observational study using survey and surveillance data.

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☒	☐ Dual use research of concern
☒	☐ Plants

Methods

n/a	Involved in the study
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☒	☐ Flow cytometry
☒	☐ MRI-based neuroimaging

Plants

Seed stocks

Report on the source of all seed stocks or other plant material used. If applicable, state the seed stock centre and catalogue number. If plant specimens were collected from the field, describe the collection location, date and sampling procedures.

Novel plant genotypes

Describe the methods by which all novel plant genotypes were produced. This includes those generated by transgenic approaches, gene editing, chemical/radiation-based mutagenesis and hybridization. For transgenic lines, describe the transformation method, the number of independent lines analyzed and the generation upon which experiments were performed. For gene-edited lines, describe the editor used, the endogenous sequence targeted for editing, the targeting guide RNA sequence (if applicable) and how the editor was applied.

Authentication

Describe any authentication procedures for each seed stock used or novel genotype generated. Describe any experiments used to assess the effect of a mutation and, where applicable, how potential secondary effects (e.g. second site T-DNA insertions, mosiacism, off-target gene editing) were examined.