Trends and risk factors of mortality and disability-adjusted life year for chronic respiratory diseases from 1990 to 2017

Journal:	*BMJ*
Manuscript ID	BMJ-2019-052342
Article Type:	Research
BMJ Journal:	BMJ
Date Submitted by the Author:	28-Aug-2019
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Keywords:	Chronic respiratory disease, Mortality, Disability-adjusted life year, Risk factor

Trends and risk factors of mortality and disability-adjusted life year for chronic respiratory diseases from 1990 to 2017

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Take-home message

The global trends of mortality and disability-adjusted life year for chronic respiratory diseases varied by age, sex, region, and disease pattern. The major risk factors of chronic obstructive pulmonary disease and asthma including environmental, behavioral, and metabolic risks were assessed.

Abstract

Background: Chronic respiratory diseases (CRDs), including chronic obstructive pulmonary disease (COPD), pneumoconiosis, asthma, and interstitial lung disease and pulmonary sarcoidosis are leading causes of mortality worldwide. However, previous analyses of worsening health and mortality caused by CRDs were based on limited data.

Methods: The mortality and disability-adjusted life year (DALY) from CRDs, COPD, pneumoconiosis, asthma, and interstitial lung disease and pulmonary sarcoidosis were estimated using DisMod-MR 2.1. The estimated annual percentage change (EAPC) of the age-standardized mortality rate (ASMR) was calculated using a generalized linear model with a Gaussian distribution.

Findings: According to the Global Burden of Diseases, Injuries, and Risk Factors Study 2017, the total number of deaths due to CRDs increased by 18.0% from 1990 to 2017. However, the ASMR of CRDs decreased globally by an average of 2.41% (95% uncertainty interval 2.27-2.56%) annually. During the past 27 years, the declines in mortality rates of COPD and pneumoconiosis have been slow, whereas, the ASMR of interstitial lung disease and pulmonary sarcoidosis has increased. There were improvements in DALY for asthma and pneumoconiosis, however, the DALY due to COPD, and interstitial lung disease and pulmonary sarcoidosis have increased. In 2017, the ASMRs of the four types of CRDs varied considerably across 195 countries. The factors responsible for the contemporary regional variations in mortality and DALY due to CRDs and the unequal distribution of the improvements in global health were assessed. The mortality increased with age, indicating a direct association between population ageing and increased disease burden. The ASMRs of COPD, pneumoconiosis, and asthma were negatively correlated with the socio-demographic index (SDI). However, there was a positive correlation between the SDI and ASMR of interstitial lung disease and pulmonary sarcoidosis. Smoking was the major risk factor of mortality due to COPD and asthma, revealing the urgent need for effective and adequately implemented smoking control programs. Particulate matter pollution contributed the most to COPD deaths in low-SDI regions. Since 2013, a high body mass

index (BMI) became the leading risk factor, thereby contributing to the ASMR of asthma.

Conclusion: This study provides a comprehensive assessment of the mortality and DALY due to CRDs in 195 countries and territories from 1990 to 2017. The estimated contribution of risk factors supports urgent efforts to reduce the exposure to risk factors such as smoking, environmental pollution, and a high BMI.

Key words

Chronic respiratory disease; Mortality; Disability-adjusted life year; Risk factor

Introduction

Chronic respiratory diseases (CRDs) pose a major public health problem with an estimated 3.91 million deaths worldwide in 2017, accounting for 7% of all deaths. COPD and asthma are the most common types of CRDs. Pneumoconiosis, and interstitial lung disease and pulmonary sarcoidosis are also global public health issues. The epidemiology of the four types of CRDs are associated with demographic trends, socio-economic development, and risk exposures, including smoking, environmental and occupational pollution, and metabolic risks. Over the past three decades, the ageing population has increased rapidly.[1] The prevalence of smoking has shown promising decline by 28.4% (95% uncertainty interval 25.8-31.1%) in males and 34.4% (95% uncertainty interval 29.4-38.6%) in females, respectively, with great geographical heterogeneity.[2] Moreover, sociodemographic development, economic shifts and risk exposures have gone through tremendous changes over the decades.[2 3] As a result, the global disease burden has changed dramatically in terms of the prevalence of CRDs. However, previous analyses of mortality and loss of health due to CRDs were based on limited data or confined to local areas.[4 5] In this study, we report the temporal and spatial trends of mortality and disability-adjusted life year (DALY) due to CRDs by age and sex across the world during 1990-2017 from the Global Burden of Diseases, Injuries, and Risk Factors Study 2017 (GBD 2017). The attribution of risk factors, including the socio-demographic index (SDI) and various risk exposures, were examined to help policymakers and services in preventing CRDs.

Method

Data source

The mortality, DALY, age-standardized mortality rates (ASMR) and age-standardized DALY rate of CRDs, including COPD, pneumoconiosis, asthma, and interstitial lung disease and pulmonary sarcoidosis in 195 countries and territories during 1990-2017 were obtained from the GBD 2017 (available online). Cases of COPD, pneumoconiosis (including asbestosis, coal workers' pneumoconiosis, silicosis, and other types of pneumoconiosis), asthma, interstitial lung disease and pulmonary sarcoidosis were identified based on the International Classification of Diseases and Injuries-10 diagnostic codes, and are listed in Supplemental Table 1.

Covariates included the SDI and risk exposures. The SDI is a composite indicator of the incomes per capita, average educational attainment, and total fertility rates.[6] The SDI values ranged from 0 to 1. According to the SDI, countries and territories were classified as high, high-middle, middle, low-middle and low SDI regions. Risk exposures were defined in the GBD comparative risk assessment framework, which includes environmental and occupational risks (particulate matter pollution, ambient ozone pollution, and occupational risks), behavioral risks (tobacco), and metabolic risks (high body mass index).

Statistical analyses

The standardized methods of the GBD 2017 have been extensively reported.[7 8] The mortality and DALY from CRDs, COPD, pneumoconiosis, asthma, and interstitial lung disease and pulmonary sarcoidosis were estimated for 195 countries and territories by age and sex from 1990 to 2017 using DisMod-MR 2.1, a Bayesian meta-regression tool. We generated 95% uncertainty intervals (UIs) for all reported data. All estimates were generated from the mean of 1000 draws, and 95% UIs were determined on the 25th and 975th ranked values of the ordered draws. The estimated annual percentage change (EAPC) of the ASMR was calculated using a generalized linear model with a Gaussian distribution.[9]

The Pearson correlation coefficient was used to measure the strength of the association

between the SDI and ASMR, and the relationship between the change in the SDI between 1990 and 2017 and the EAPC of ASMR during 1990-2017. A P value of less than 0.05 was regarded as statistically significant.

Results

Disease burden and mortality estimates

Approximately 2.87 billion DALYs were attributed to CRDs from 1990 to 2017 worldwide. An improvement in DALY was observed in patients with asthma and pneumoconiosis, whereas patients with COPD, and interstitial lung disease and pulmonary sarcoidosis showed worsening health (Suppl. Table 2).

Nearly 100 million deaths due to CRDs occurred globally during the past 27 years. The number of CRD deaths increased by 18.0%, from 3,317.2 (95% UI 3,011.6-3,425.4) thousand in 1990 to 3,914.2 (95% UI 3,790.6-4,044.8) thousand in 2017. Nevertheless, the ASMR declined by an average of 2.41% (95% UI 2.27-2.56%) during the same period and differed significantly between males and females both in 1990 and 2017. In 2017, 3,197.8 (95% UI 3,029.0-3,358.9) thousand people died of COPD, accounting for 81.7% of the total number of deaths from CRDs.

The number of deaths due to COPD in 2017 corresponded to a 23% increase compared with that in 1990. Figure 1a provides a global view of a wide range of ASMR attributed to COPD in 2017. The ASMR was highest in Papua New Guinea (229.9 [95% UI 192.8-274.0] per 100,000 people), followed by North Korea (153.7 [95% UI 123.6-210.1] per 100,000 people) and India (113.7 [95% UI 94.0-127.5] per 100,000 people). The countries with the lowest ASMRs were Kuwait (4.50 [95% UI 4.07-4.97] per 100,000 people) , Iraq (6.28 [95% UI 5.78-7.32] per 100,000 people) and Japan (7.11 [95% UI 6.61-7.99] per 100,000 people). From 1990 to 2017, the global ASMR dropped by an average of 2.36% (95% UI 2.21-2.50%), which was represented by the EAPC. The greatest improvement in the ASMR was observed in Singapore (EAPC=-6.69, 95% UI -6.51 to -6.86), followed by two neighboring countries, Ukraine (EAPC=-6.31, 95% UI -5.70 to -6.91) and Belarus (EAPC=-6.28, 95% UI -5.66 to -6.90) (Fig. 1c). Nevertheless, the ASMR in Georgia was significantly increased (EAPC=4.00, 95% UI

2.69-5.31), followed by two neighboring countries, Norway (EAPC=1.77, 95% UI 1.28-2.27) and Sweden (EAPC=1.12, 95% UI 0.80-1.46).

In 2017, 21,551.6 (95% UI 20,469.1-22,694.4) deaths were attributed to pneumoconiosis. The ASMR of pneumoconiosis varied widely among countries (Suppl. Fig. 1a), with the highest ASMR in Papua New Guinea (1.76 [95% UI 1.23-2.50] per 100,000 people) and the lowest ASMR in Moldova (0.0041 [95% UI 0.0035-0.0048] per 100,000 people). The ASMR decreased from 0.52 (95% UI 0.44-0.61) per 100,000 people to 0.28 (95% UI 0.26-0.29) per 100,000 people globally, with an average decrease of 2.57% (95% UI 2.45-2.69%) from 1990 to 2017, as shown in Supplemental Figure 1c. The largest improvement in the ASMR was found in Macedonia (EAPC=-11.10, 95% UI -11.96 to -10.24), followed by Jamaica (EAPC=-10.96, 95% UI -13.24 to -8.63) and Latvia (EAPC=-9.99, 95% UI -10.69 to -9.30). The ASMR also increased in 32 countries, and a significant increase was noted in Georgia (EAPC=3.99, 95% UI 2.25-5.76), followed by New Zealand (EAPC=3.71, 95% UI 3.11-4.30) and Croatia (EAPC=3.07, 95% UI=2.07-4.09).

Supplemental Figure 2a shows the global ASMR of asthma with a large difference in the regional distribution in 2017. The highest ASMR was observed in Papua New Guinea (95.43 [95% UI 49.09-138.82] per 100,000 people), and the lowest ASMR was noted in Italy (0.26 [95% UI 0.23-0.29] per 100,000 people). There was an average decrease of 3.40% (95% UI 3.25-3.56%) in the global ASMR from 1990 to 2017. The largest improvement in the ASMR was found in Korea (EAPC=-10.42, 95% UI -11.31 to -9.52), followed by Belarus (EAPC=-10.15, 95% UI -10.96 to -9.33) and Qatar (EAPC=-9.74, 95% UI -10.54 to -8.94). The ASMR was increased in two countries only, Zimbabwe (EAPC=1.80, 95% UI 0.89-2.71) and Lesotho (EAPC=0.51, 95% UI 0.07-0.94) (Suppl. Fig. 2c).

Unlike other CRDs, the global ASMR due to interstitial lung disease and pulmonary sarcoidosis increased at an average of 0.97% (95% UI 0.92-1.03%) from 1990 to 2017. The greatest increase in the ASMR was observed in Greece (EAPC=5.63, 95% UI 5.19-6.07), followed by Ecuador (EAPC=4.81, 95% UI 4.21-5.42) and El Salvador

(EAPC=4.75, 95% UI 4.17-5.34). The countries with a significant improvement in the ASMR were Russia (EAPC=-7.81, 95% UI -9.06 to -6.55), Belarus (EAPC=-7.62, 95% UI -8.10 to -7.14) and Kyrgyzstan (EAPC=-5.79, 95% UI -6.45 to -5.12). In 2017, the countries with the three highest ASMRs were Peru (12.10 [95% UI 7.74-14.53] per 100,000 people), Bolivia (8.38 [95% UI 6.43-10.74] per 100,000 people) and Maldives (6.89 [95% UI 5.71-8.76] per 100,000 people), whereas, the lowest ASMRs were reported in Burkina Faso (0.23 [95% UI 0.13-0.39] per 100,000 people), Moldova (0.24 [95% UI 0.18-0.36] per 100,000 people) and Liberia (0.26 [95% UI 0.15-0.39] per 100,000 people).

Sex and age differences in mortality and DALY

Significant decreases were observed in the age-standardized DALY rates and ASMRs of CRDs for both sexes from 1990 to 2017 (Fig. 2). Generally, the ASMR of CRDs showed that males had a higher mortality rate than females. For asthma, the mortality gap between males and females was narrowed during 1990-2017, suggesting that the mortality rate dropped faster in males than females.

Globally, the deaths attributed to COPD, pneumoconiosis, asthma, and interstitial lung disease and pulmonary sarcoidosis in 1990 and 2017 by age and sex are shown in Supplemental Figure 4 and Figure 3. The number of deaths from the four types of CRDs increased with age and rose sharply in those aged 70 years and older, although asthma is more common among children than adults.

Correlation between the SDI and estimates of mortality and DALY

The relationships between the SDI and ASMRs due to COPD, pneumoconiosis, asthma, and interstitial lung disease and pulmonary sarcoidosis are shown in Figure 4. For COPD and asthma, the ASMRs showed a downward trend for all five SDI regions, decreasing from low SDI regions to high SDI regions. There were strong negative correlations between the ASMRs and SDI (Fig. 5). For pneumoconiosis, a negative relationship between the ASMR and SDI was revealed. Nevertheless, the ASMR in high SDI regions was higher than those in low-middle and high-middle SDI regions. Notably, the ASMR of interstitial lung disease and pulmonary sarcoidosis was

positively associated with the SDI. Except for high-middle SDI regions, the ASMRs in four other SDI regions showed an increasing trend from 1990 to 2017. No correlation was observed between the EAPC in the ASMRs of four types of CRDs during 1990-2017 and the change in the SDI between 1990 and 2017 (Suppl. Fig. 5). Similarly, the relationship between the SDI and age-standardized DALY rates resembled those between the SDI and ASMRs of the four types of CRDs (Suppl. Fig. 6; Suppl. Fig. 7).

Risk factors

In 2017, the leading risk factor of COPD deaths and disability was tobacco use, accounting for 1.41 (95% UI 1.27–1.54) million COPD deaths and 33.01 (95% UI 28.94-36.51) million DALYs, followed by particulate matter pollution (1.00 [0.69–1.28] million deaths and 25.12 [17.26–31.94] million DALYs) (Fig. 6a; Suppl. Fig. 8). Besides smoking, the mortality attributed to secondhand smoke was too great to ignore. In 2017, nearly one-fifth of deaths from COPD were due to secondhand smoke (Fig. 6b). According to the findings, the impact of secondhand smoke exposure on death from COPD in females was far more devastating than that on death in males. Although the rate continued to decline in both sexes, a more profound decline occurred in males. Therefore, sex-related disparities in deaths due to COPD attributed to tobacco use narrowed over time (Fig. 6c). From 1990 to 2017, the ASMR attributed to household air pollution from solid fuels decreased by 73.5%, whereas ambient particulate matter pollution became the major risk factor for COPD deaths since 2002 (Fig. 6d).

Significant negative correlations between the SDI and ASMR of COPD attributed to the four types of risk factors were also observed (Fig. 7). With regard to particulate matter pollution ($R=-0.5476$, $p<0.0001$) and occupational risks ($R=-0.4854$, $p<0.0001$), the correlations were moderate. In high and middle SDI regions, tobacco was the most important risk factor for death from COPD (Fig. 8a). Tobacco-attributable deaths decreased as the SDI declined. Particulate matter pollution explained most of the deaths from COPD in low-SDI regions.

In 1990, the main level 4 risk factor for the ASMR and age-standardized DALY rate of asthma was smoking (Suppl. Fig. 8; Suppl. Fig. 9a). The smoking-attributable ASMR declined by 68.7% from 2.36 (95% UI 1.12-3.54) per 100,000 people in 1990 to 0.74 (95% UI 0.37-1.14) per 100,000 people in 2017. Sex disparities in the number of asthma deaths attributed to smoking had decreased significantly during the past 27 years (Suppl. Fig. 9b). Furthermore, a high body mass index (BMI) was identified as the most critical risk factor for DALY of asthma since 2003, accounting for the most deaths from asthma since 2013 (Suppl. Fig. 8b; Suppl. Fig. 9a). The ASMR of asthma attributed to the high BMI in males showed a sharp decline, and it was lower in males than that in females since 2011 (Suppl. Fig. 9c). Occupational asthmagens are also strong risk factors for asthma, explaining 6.7% of the asthma deaths in 2017.

Significant negative correlations were observed between the SDI and ASMRs of asthma attributed to smoking, a high BMI and occupational asthmagens, whereas the corresponding correlations were weak ($R=-0.351$, $p<0.0001$), moderate ($R=-0.4439$, $p<0.0001$) and strong ($R=-0.7489$, $p<0.0001$), respectively (Suppl. Fig. 10). In low-SDI countries, smoking was the most important risk factor, whereas a high BMI accounted for most mortality in high and middle SDI regions (Fig. 8b).

Disscussion

The burden of CRDs from 1990 to 2017 was described at global and national levels in this study. Increasing trends for mortality and health loss due to CRDs were observed. However, the ASMR and age-standardized DALY rate due to CRDs decreased from 1990 to 2017. Contrary to three other types of CRDs, interstitial lung disease and pulmonary sarcoidosis showed increasing trends in ASMR and age-standardized DALY rate.

To investigate the explanatory factors related to the changes in mortality and DALY due to CRDs from 1990 to 2017, the effects of sex, age, social development, and risk exposures were examined. Differences in the ASMR due to CRDs between males and females were observed, especially in COPD and pneumoconiosis. As a remarkable male predominance was observed in the morbidity of COPD and pneumoconiosis, the

relatively higher death rates observed in males may be related to the higher prevalence of CRDs in males than females.

In 1990 and 2017, deaths from CRDs increased with age, especially in people aged 70 years and older. Although the age trends between the prevalence and mortality of asthma were opposite, the prevalence and mortality of three other CRDs were largely consistant and age-dependent. Therefore, the heavy burden of CRDs is likely to increase as the pace of population ageing worldwide.

In 2017, CRDs represented an important public health concern as leading causes of disease burden with a large proportion attributed to COPD and asthma. COPD was responsible for an estimated 3.2 million deaths, accounting for 81.7% of the total deaths caused by CRDs. Moreover, considerable heterogeneity in the ASMR of the four types of CRDs existed across different countries in 2017. The countries with the highest ASMR exhibited more than 50-fold higher rates of deaths. The SDI was identified as a key factor that affected the death rate and lose of health, possibly explaining regional variations. Negative correlations between the SDI and ASMRs of COPD, pneumoconiosis, and asthma were observed, whereas the SDI was positively correlated with the ASMR of interstitial lung disease and pulmonary sarcoidosis. Consistently, the associations between the SDI and age-standardized DALY rates were similar with those beween the SDI and ASMRs of the four types of CRDs. As no associations between the SDI and incidences of COPD and pneumoconiosis were observed in our previous study (unpublished), the low mortality from CRDs in high SDI countries reflects better access to health services and improved treatment options. However, as the SDI increased, the burden of intersitial lung disease and pulmonary sarcoidosis increased. Therefore, intersitial lung disease and pulmonary sarcoidosis are expected to impose increasing substantial socioeconomic burdens on individuals and societies due to the growing trend of the global SDI.

Smoking is a major risk factor for COPD, but other environmental and occupational exposures may also contribute to the disease. According to the GBD 2017, the leading cause of mortality and loss of health in COPD was tobacco use. Aside from smoking,

exposure to secondhand smoke is also an important contributing factor. Interestingly, the impact of secondhand smoke exposure was more severe in females. Globally, more than a third of children and non-smokers are regularly exposed to secondhand smoke.[10] Tobacco use is a severe public health problem, especially in low- and middle-income countries. Our findings showed that the ASMR of COPD attributable to tobacco use was negatively correlated with the SDI in 2017. However, tobacco use was the major risk facor of mortality from COPD, and the greatest barrier in COPD prevention and management for high and middle SDI regions, which may be explained by the fact that population ageing offsets the gains of the declines in the prevalence of smoking and mortality rates in these regions.[2]

Long-term exposure to air pollution was reported to increase mortality from COPD. As the proportion of households cooking with solid fuels decreased worldwide,[11] ambient particulate matter pollution has been the predominant risk factor for mortality from COPD since 2002. A strong negative relationship between the ASMR attributable to particulate matter pollution and SDI was observed. Consistently, particulate matter pollution contributed the most to COPD deaths in low-SDI regions.

Ambient ozone is the second most important air pollutant after particulate matter. There is compelling evidence to indicate that ambient ozone increased the death rate from chronic low respiratory diseases.[12] The health effects were related to ozone exposure, even at concentrations below national standards in the United States, which was most pronounced for low-income people.[13] Our study revealed a negative correlation between the ASMR attributable to ambient ozone and SDI in 2017.

It was estimated that more than 20% of COPD cases in 2010 were attibutable to occupational exposure.[14] An additive effect of smoking and occupational exposure was oberved, thereby increasing the risk for COPD.[14 15] During the past 27 years, the ASMR attributable to occupational risks decreased, and was negatively associated with the SDI in 2017.

Besides COPD, smoking can cause other respiratory diseases such as asthma. Parental smoking was reported to be related to the risk of developing asthma in offspring.[16] A

16-year prospective cohort study showed that smoking contributed to the incidence of adult-onset asthma.[17] Our study showed that smoking was the major risk factor for mortality and loss of health in patients with asthma until 2013. A negative relationship between the SDI and mortality rate attributable to smoking was revealed. Furthermore, smoking was identified as the largest contributor to asthma-related deaths in low-SDI regions, which indicates that smoking has a greater impact on asthma in developing countries.

Previous studies revealed an association between a high BMI and asthma, which was more significant in females,[18] middle-aged individuals and the elderly.[19] Maternal obesity poses an increased risk for asthma in children.[20] Obese patients had a higher risk of exacerbations and poorer asthma control.[21] Moreover, the positive effects of weight loss on outcomes related to asthma have been confirmed.[22] According to the GBD 2017, a high BMI accounted for the most deaths caused by asthma since 2013 and contributed the most to DALYs since 2003. However, obesity was not widely recognized as a modifiable risk factor like smoking. As the prevalence of obesity continues to increase at an alarming rate worldwide, weight loss should be included in the management of obese patients with asthma. From 1990 to 2017, high BMI-related mortality showed a decreasing trend and the slope was steeper in males, which resembles the temporal trend in mortality from asthma attributable to smoking. The impact of obesity on asthma was more significant in females than that in males since 2010. The ASMR attributable to a high BMI was negatively associated with the SDI in 2017. The proportion of asthma-related mortality explained by a high BMI was highest in high and middle SDI regions.

Occupational asthmagens are the second largest environmental and occupational risk factors for asthma. Occupational exposure to asthmagens, including gas, smoke, dust, and other agents, were associated with the exacerbation[23] and uncontrolled adult-onset of asthma.[24] The number of suspected and recognized asthmagens has tripled since 2000, which is likely to improve the occupational exposure assessment of asthma in the future.

The limitations of our study were the case definitions of various CRDs. Civil registration and vital statistics (CRVS) systems are key sources of vital statistics for mortality rates. However, the population coverage with well-functioning CRVS systems has been disappointing. Verbal autopsy, which can not accurately determine the cause of death, is currently the best option for estimating the mortality rate in countries without fully functional vital registration systems. As CRVS systems provide essential information for public health policies and disease preventions,[25] the strengthening of CRVS systems is important for public health.

Conclusion

This study showed that the global deaths and DALY from CRDs increased from 1990 to 2017, while the ASMR and age-standardized DALY rate decreased, with a more profound decline in males. Overall, the low SDI was the single most important obstacle in the further decline of mortality in developing countries. Ageing and risk exposures including smoking, environmental pollution, and a high BMI, were the big drivers of mortality, and they should receive more attention with supportive policies.

Disclosure Statement

The authors have no conflict of interest to declare regarding the publication of this manuscript.

Contributorship

Xiaochen Li conceived the study and drafted the manuscript; Xiaochen Li and Min Xie collected and analyzed the data.Min Xie and Xiansheng Liu revised and approved the final version of the manuscript. Xiaopei Cao and Mingzhou Guo participated in the data preparation and provided important comments on the manuscript.

Acknowledgment

This project was supported by grants from the National Natural Science Foundation of China (81700052).

Ethical approval information

This manuscript does not contain personal or medical information about an identifiable living individual, and animal subjects were not involved in the study.

Data sharing statement

All data is available on the internet. (URL: http://ghdx.healthdata.org/gbd-results-tool)

Patient and Public Involvement

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination of our research.

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Figure legends

Figure 1

The global mortality rate of chronic obstructive pulmonary disease (COPD) for both sexes in 195 countries and territories.

a. The age-standardized mortality rate (ASMR) of COPD for both sexes combinded in 2017.

b. The relative percentage change in the ASMR of COPD for both sexes between 1990 and 2017.

c. The estimated annual percentage change (EAPC) in the ASMR of COPD for both sexes from 1990 to 2017.

COPD, chronic obstructive pulmonary disease; ASMR, age-standardized mortality rate; EAPC, estimated annual percentage change

Figure 2

a-b. The age-standardized disability-adjusted life year (DALY) and age-standardized mortality rate (ASMR) of chronic respiratory diseases by sex from 1990 to 2017.

c-f. The age-standardized mortality rates (ASMRs) of chronic obstructive pulmonary disease (COPD), pneumoconiosis, asthma, and interstitial lung disease and pulmonary sarcoidosis by sex from 1990 to 2017.

DALY, disability-adjusted life year; ASMR, age-standardized mortality rate; COPD, chronic obstructive pulmonary disease.

Figure 3

The global mortality rates of chronic obstructive pulmonary disease (COPD) (a), pneumoconiosis (b), asthma (c), and interstitial lung disease and pulmonary sarcoidosis (d) by age and sex in 2017.

The shading indicates 95% uncertainty intervals.

COPD, chronic obstructive pulmonary disease.

Figure 4

The age-standardized mortality rates (ASMRs) of chronic obstructive pulmonary disease (COPD) (a), pneumoconiosis (b), asthma (c), and interstitial lung disease and pulmonary sarcoidosis (d) grouped by sociodemographic index (SDI) quintiles from 1990 to 2017.

COPD, chronic obstructive pulmonary disease; ASMR, age-standardized mortality rate; SDI, socio-demographic index.

Figure 5

The correlation between the sociodemographic index (SDI) and age-standardized mortality rate (ASMR) of chronic obstructive pulmonary disease (COPD) (a), pneumoconiosis (b), asthma (c) and interstitial lung disease and pulmonary sarcoidosis (d) in 2017.

SDI, socio-demographic index; ASMR, age-standardized mortality rate; COPD, chronic obstructive pulmonary disease.

Figure 6

a. The age-standardized mortality rate (ASMR) of chronic obstructive pulmonary disease (COPD) attributable to the four types of risk factors in both sexes from 1990 to 2017.

b. The ASMR of COPD attributable to tobacco, smoking and secondhand smoke in both sexes from 1990 to 2017.

c. The ASMR of COPD attributable to smoking and secondhand smoke by sex from 1990 to 2017.

d. The ASMR of COPD attributable to particulate matter pollution, ambient particulate matter pollution and household air pollution from solid fuels for both sexes from 1990 to 2017.

ASMR, age-standardized mortality rate; COPD, chronic obstructive pulmonary disease.

Figure 7

The correlation between the sociodemographic index (SDI) and age-standardized mortality rate (ASMR) of chronic obstructive pulmonary disease (COPD) attributable to tobacco (a), particulate matter pollution (b), occupational risks (c), and ambient ozone pollution (d) in 2017.

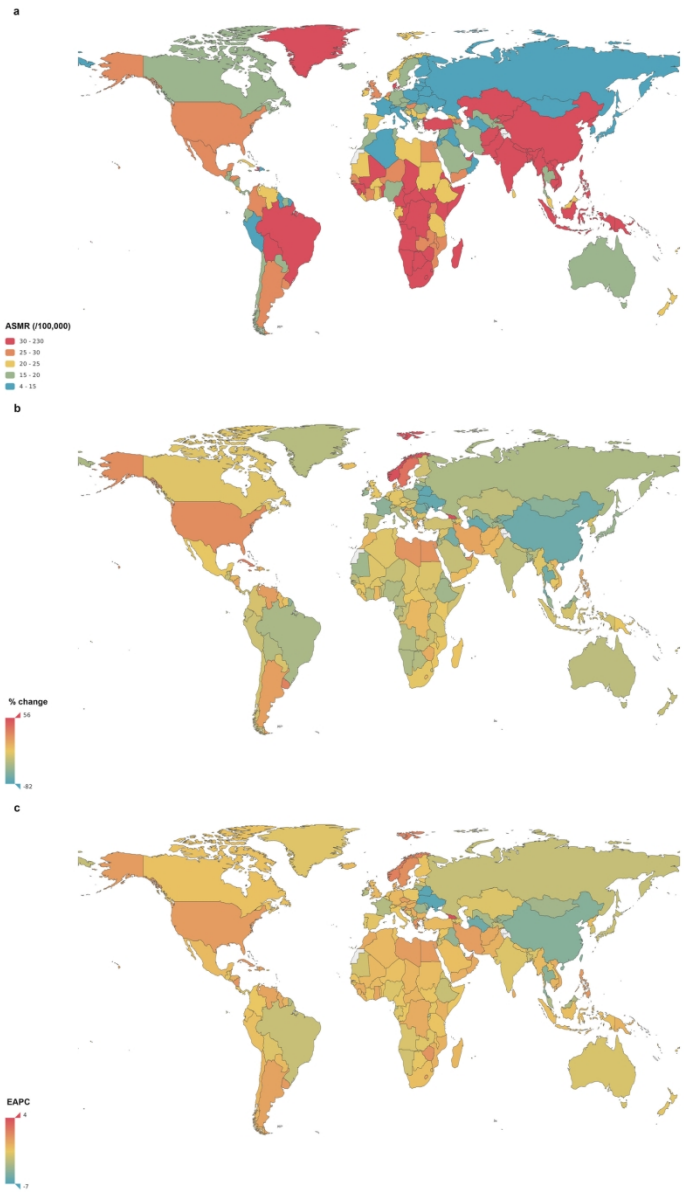
SDI, socio-demographic index; ASMR, age-standardized mortality rate; COPD, chronic obstructive pulmonary disease.

Figure 8

a. The contribution of particulate matter pollution, occupational risks, and ambient ozone pollution to the age-standardized mortality rate (ASMR) of chronic obstructive pulmonary disease (COPD) in locations grouped by sociodemographic index (SDI) quintiles in 2017.

b. The contribution of occupational asthmagens and high body mass index to the ASMR of asthma in locations grouped by sociodemographic index (SDI) quintiles in 2017.

ASMR, age-standardized mortality rate; COPD, chronic obstructive pulmonary disease; SDI, socio-demographic index.



The global mortality rate of chronic obstructive pulmonary disease (COPD) for both sexes in 195 countries and territories.

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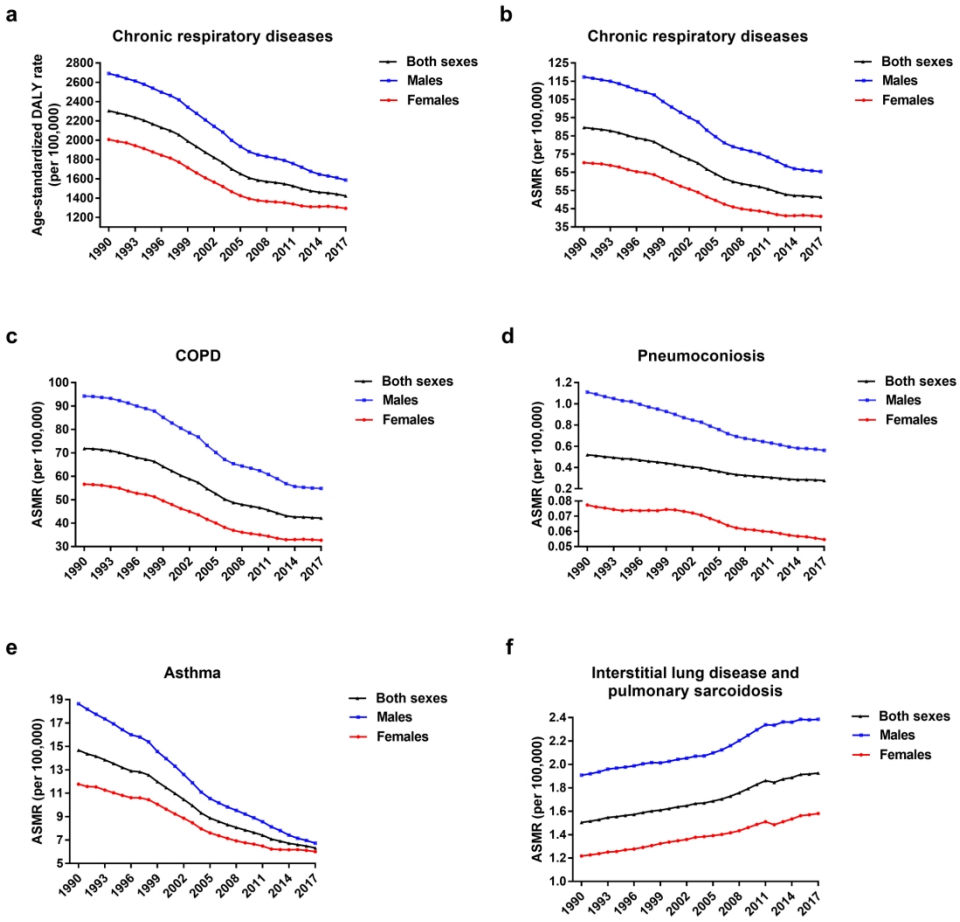

a-b. The age-standardized disability-adjusted life year (DALY) and age-standardized mortality rate (ASMR) of chronic respiratory diseases by sex from 1990 to 2017.
c-f. The age-standardized mortality rates (ASMRs) of chronic obstructive pulmonary disease (COPD), pneumoconiosis, asthma, and interstitial lung disease and pulmonary sarcoidosis by sex from 1990 to 2017.

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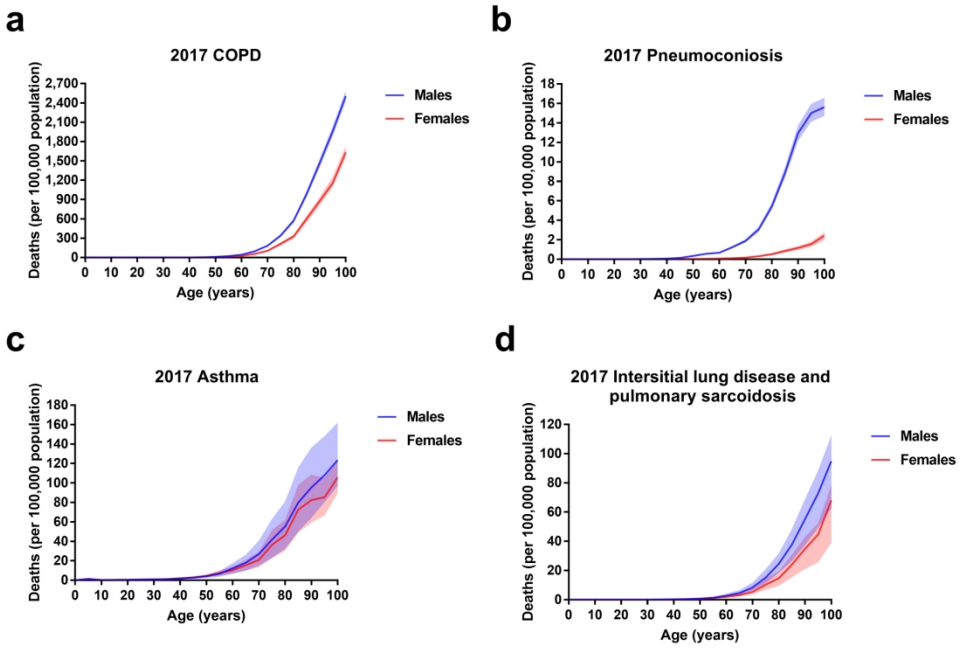

The global mortality rates of chronic obstructive pulmonary disease (COPD) (a), pneumoconiosis (b), asthma (c), and interstitial lung disease and pulmonary sarcoidosis (d) by age and sex in 2017.

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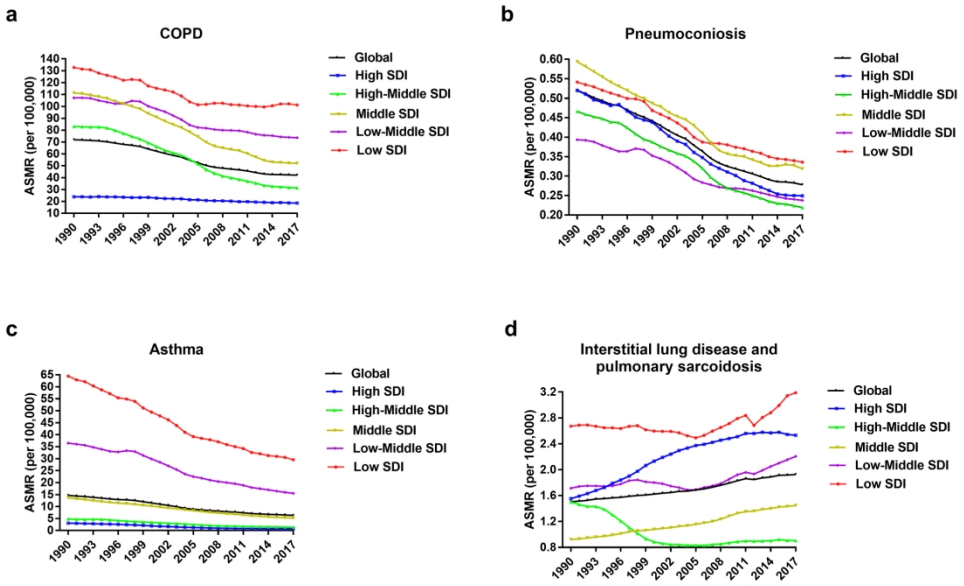

The age-standardized mortality rates (ASMRs) of chronic obstructive pulmonary disease (COPD) (a), pneumoconiosis (b), asthma (c), and interstitial lung disease and pulmonary sarcoidosis (d) grouped by sociodemographic index (SDI) quintiles from 1990 to 2017.

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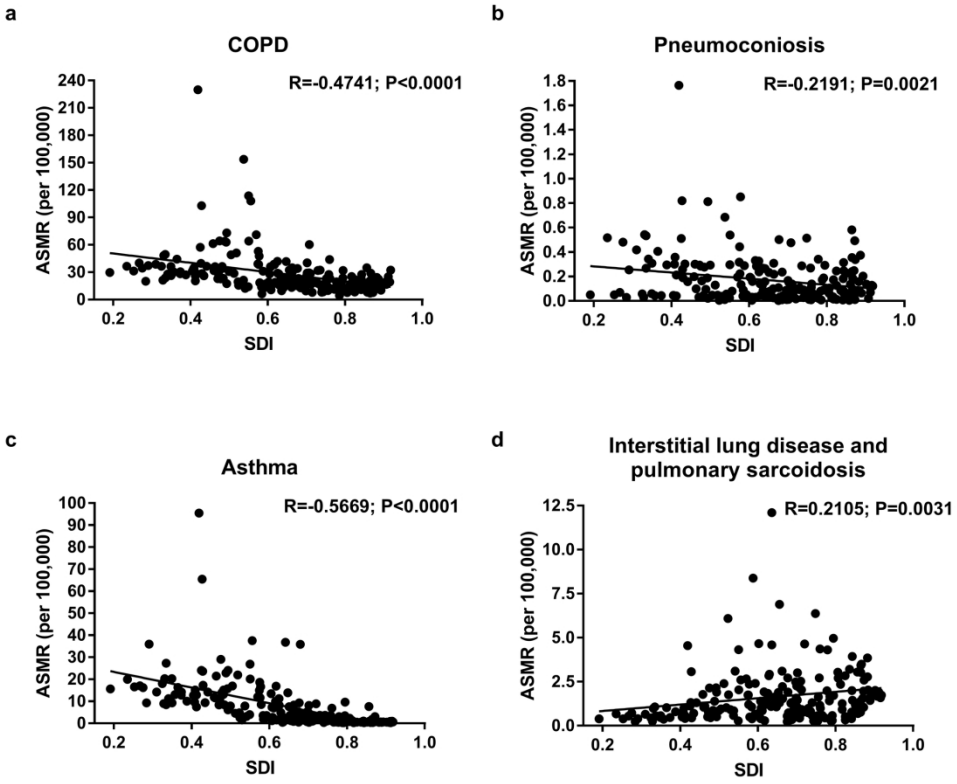

The correlation between the sociodemographic index (SDI) and age-standardized mortality rate (ASMR) of chronic obstructive pulmonary disease (COPD) (a), pneumoconiosis (b), asthma (c) and interstitial lung disease and pulmonary sarcoidosis (d) in 2017.

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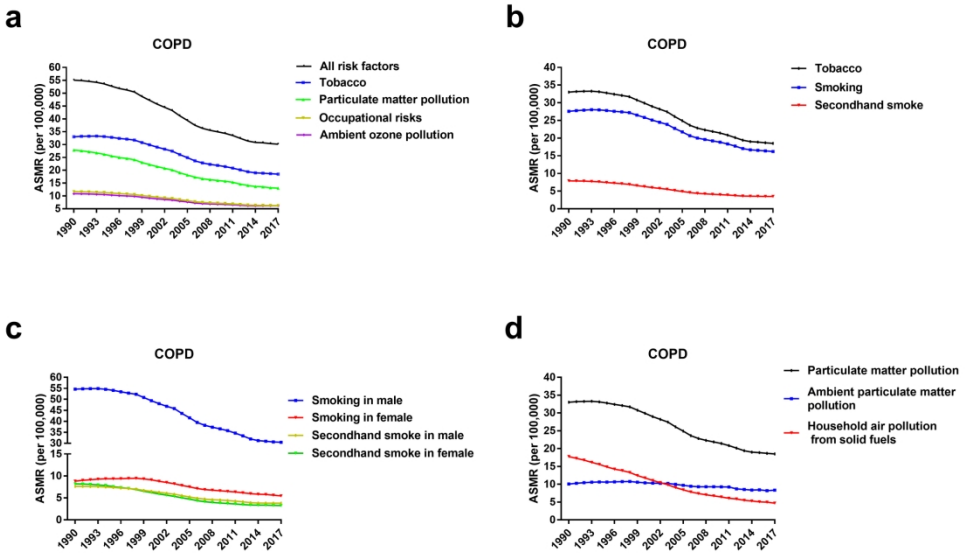

a. The age-standardized mortality rate (ASMR) of chronic obstructive pulmonary disease (COPD) attributable to the four types of risk factors in both sexes from 1990 to 2017.
b. The ASMR of COPD attributable to tobacco, smoking and secondhand smoke in both sexes from 1990 to 2017.
c. The ASMR of COPD attributable to smoking and secondhand smoke by sex from 1990 to 2017.
d. The ASMR of COPD attributable to particulate matter pollution, ambient particulate matter pollution and household air pollution from solid fuels for both sexes from 1990 to 2017.

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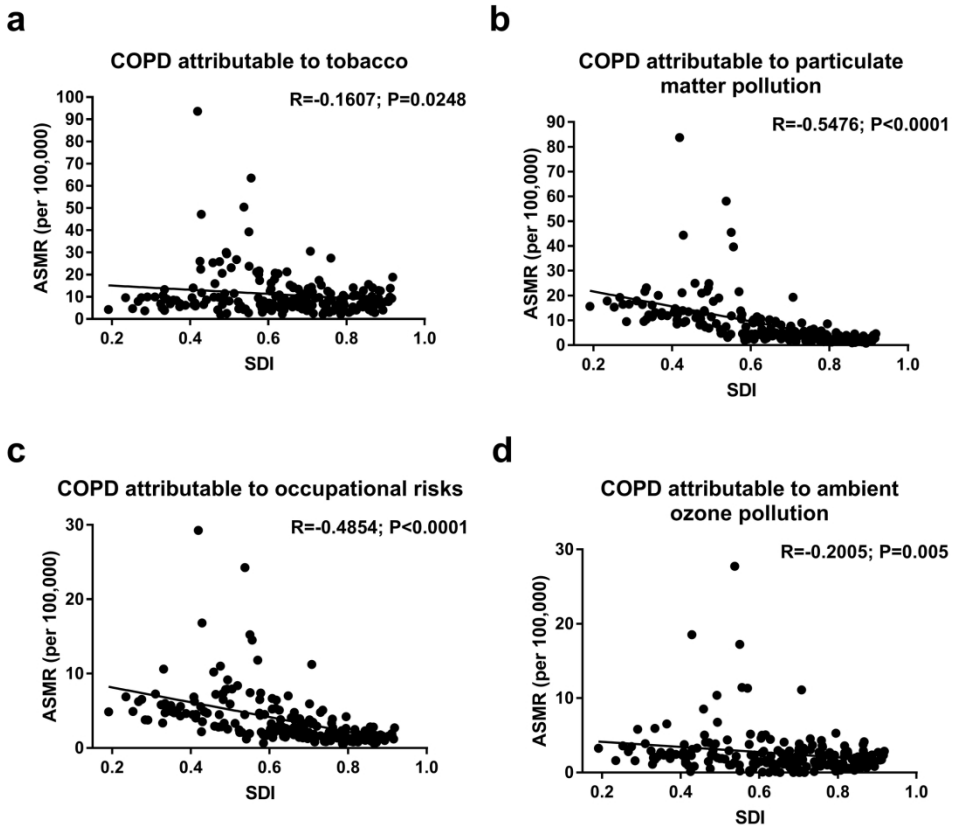

The correlation between the sociodemographic index (SDI) and age-standardized mortality rate (ASMR) of chronic obstructive pulmonary disease (COPD) attributable to tobacco (a), particulate matter pollution (b), occupational risks (c), and ambient ozone pollution (d) in 2017.

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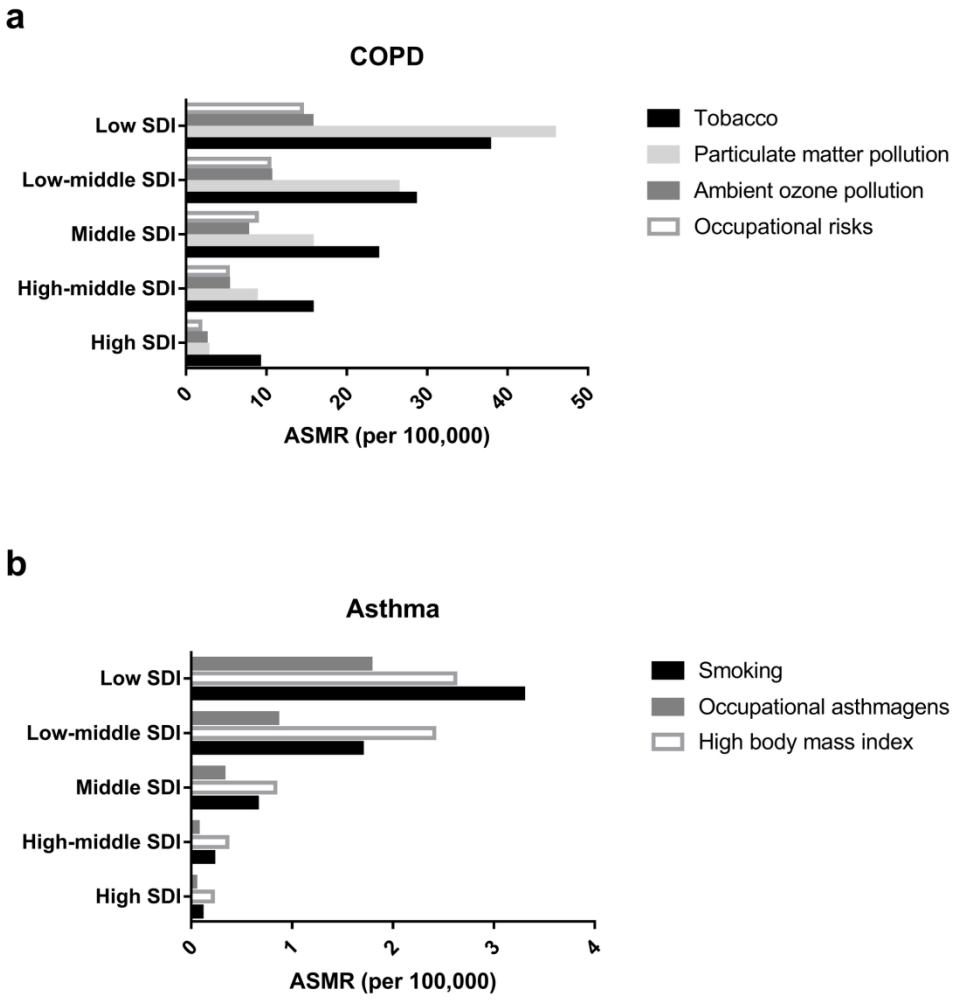

a. The contribution of particulate matter pollution, occupational risks, and ambient ozone pollution to the age-standardized mortality rate (ASMR) of chronic obstructive pulmonary disease (COPD) in locations grouped by sociodemographic index (SDI) quintiles in 2017.
b. The contribution of occupational asthmagens and high body mass index to the ASMR of asthma in locations grouped by sociodemographic index (SDI) quintiles in 2017.

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S-table 1. International Classification of Diseases and Injuries-10 (ICD-10) diagnosis code

Cause	ICD-10
Chronic obstructive pulmonary disease	J40-J44.9; J47-J47.9
Pneumoconiosis	J60-63.8; J65-J65.0; J92.0
Silicosis	J62-J62.9
Asbestosis	J61-J61.0; J92.0
Coal workers pneumoconiosis	J60-J60.0
Other pneumoconiosis	J63-63.8; J65-65.0
Asthma	J45-J46.9
Interstitial lung disease and pulmonary sarcoidosis	D86-86.2; D86.89-D86.9; J84-J84.9

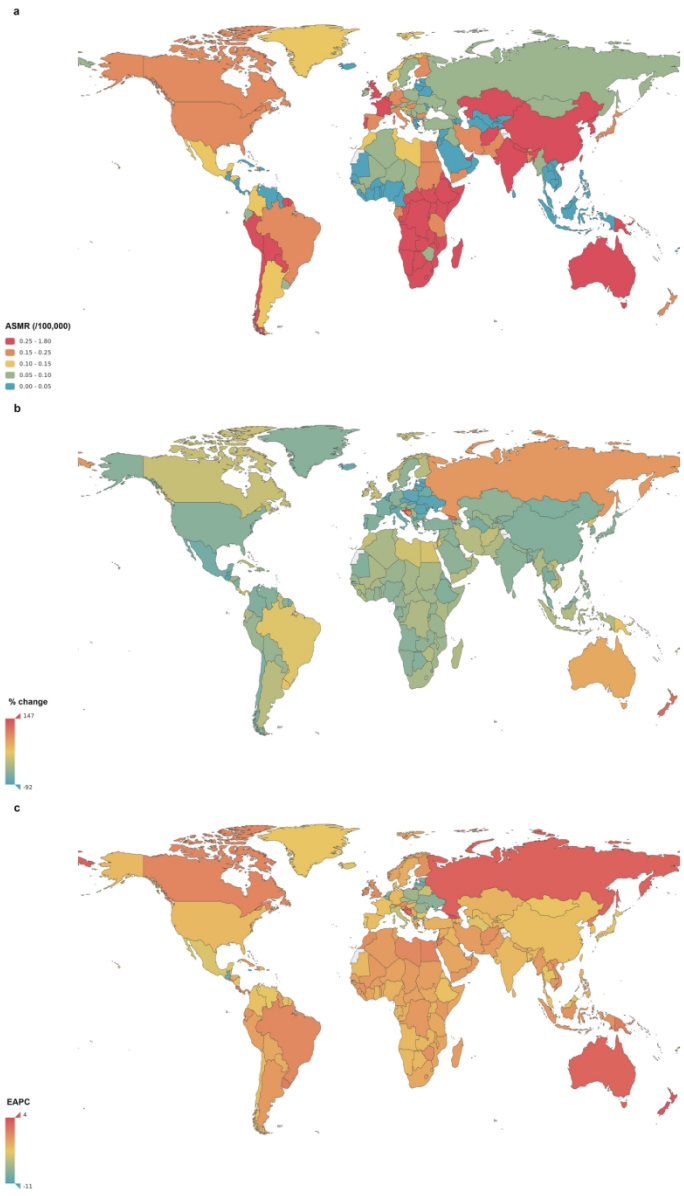
Supplemental table 2. The global mortality, ASMR, and DALY due to chronic respiratory diseases in 1990 and 2017

			Chronic respiratory diseases	Chronic obstructive pulmonary disease	Pneumoconiosis					Asthma	Interstitial lung disease and pulmonary sarcoidosis
					Overall	Silicosis	Asbestosis	Coal workers pneumoconiosis	Other pneumoconiosis		
1990	**DALY×10^3**		99103.9 (91717.1-104764.8)*	68185.2 (61536.4-74688.2)	519.4 (436.3-604.2)	288.4 (227.2-358.4)	38.1 (26.7-50.4)	113.0 (78.9-162.3)	79.9 (55.7-106.9)	26051.1 (19948.4-31277.9)	1589.9 (1207.2-2129.0)
	No. death×10^3		3317.2 (3011.6-3425.4)	2600.1 (2289.0-2860.1)	20.4 (17.2-24.0)	11.5 (9.1-14.3)	1.4 (1.0-2.0)	4.8 (3.4-6.7)	2.7 (1.9-3.6)	599.3 (336.2-771.3)	56.4 (42.3-75.0)
	ASMR (per 100,000)	**both sexes**	89.53 (81.20-92.47)	71.88 (63.56-78.63)	0.52 (0.44-0.61)	0.29 (0.23-0.36)	0.04 (0.03-0.05)	0.13 (0.09-0.18)	0.07 (0.05-0.09)	14.68 (8.26-19.08)	1.50 (1.14-1.96)
		male	117.29 (112.76-121.35)	94.24 (85.85-103.04)	1.11 (0.92-1.34)	0.64 (0.51-0.80)	0.08 (0.05-0.11)	0.29 (0.20-0.40)	0.11 (0.06-0.17)	18.64 (8.40-27.28)	1.91 (1.39-3.02)
		female	70.322 (55.039-74.968)	56.635 (42.112-64.851)	0.077 (0.048-0.102)	0.021 (0.013-0.029)	0.012 (0.007-0.020)	0.010 (0.004-0.017)	0.034 (0.018-0.049)	11.778 (7.282-15.438)	1.218 (0.799-2.004)

2017	**DALY×10³**		112316.8 (104649.7-119692.8)	81601.5 (75982.1-86757.7)	507.4 (472.0-547.8)	260.6 (233.3-286.4)	69.1 (52.2-81.4)	80.8 (69.0-100.1)	96.9 (81.8-117.1)	22762.8 (180.8-28337.2)	3365.0 (2765.1-4082.1)
	No. death×10³		3914.2 (3790.6-4044.8)	3197.8 (3029.0-3358.9)	21.6 (20.5-22.7)	11.3 (10.4-12.5)	3.4 (2.3-3.9)	3.2 (2.9-4.0)	3.6 (3.1-4.5)	495.1 (338.2-641.2)	147.6 (115.0-181.3)
	ASMR (per 100,000)	**both sexes**	51.36 (49.75-53.07)	42.16 (40.01-44.20)	0.28 (0.26-0.29)	0.14 (0.13-0.16)	0.04 (0.03-0.05)	0.04 (0.04-0.05)	0.05 (0.04-0.06)	6.33 (4.34-8.17)	1.93 (1.49-2.36)
		male	65.43 (62.95-67.28)	54.81 (51.46-57.64)	0.56 (0.53-0.59)	0.31 (0.28-0.34)	0.09 (0.06-0.11)	0.09 (0.08-0.11)	0.08 (0.06-0.10)	6.74 (4.03-9.44)	2.38 (1.82-3.09)
		female	40.793 (37.917-43.809)	32.710 (29.718-35.261)	0.055 (0.045-0.063)	0.014 (0.009-0.020)	0.011 (0.006-0.014)	0.006 (0.003-0.008)	0.023 (0.018-0.030)	6.005 (4.112-7.834)	1.580 (1.059-2.108)

*Data in parentheses shown as 95% UI.

DALY, disability-adjusted life year; ASMR, age-standardized mortality rate.



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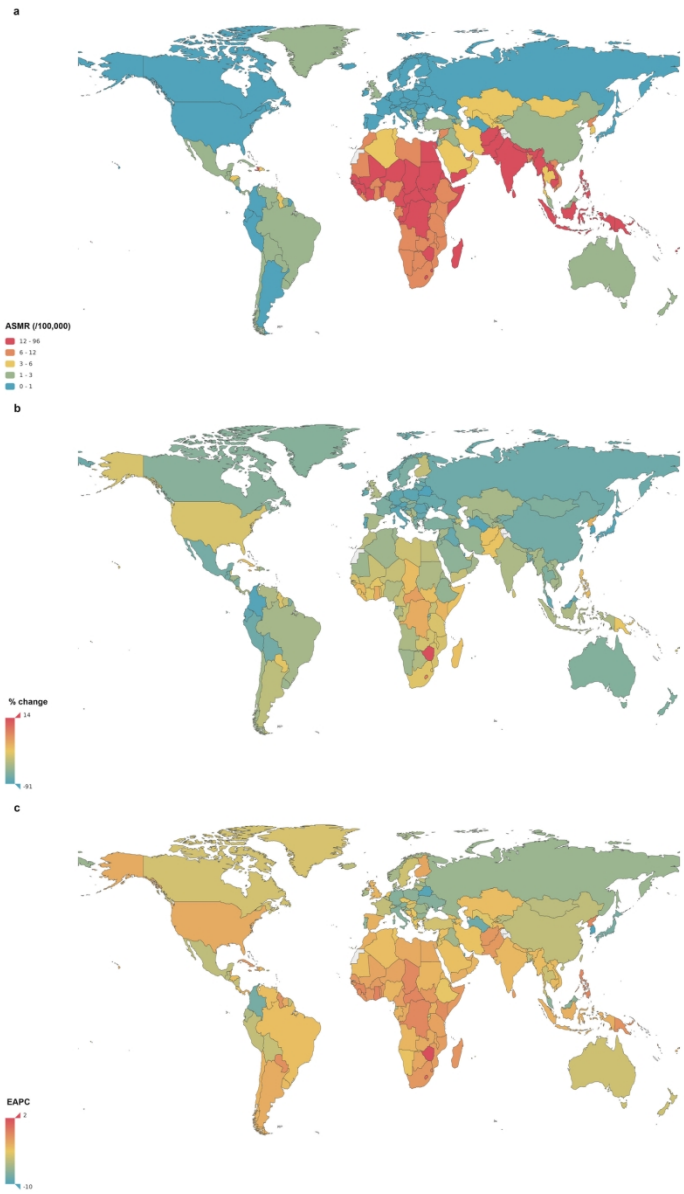

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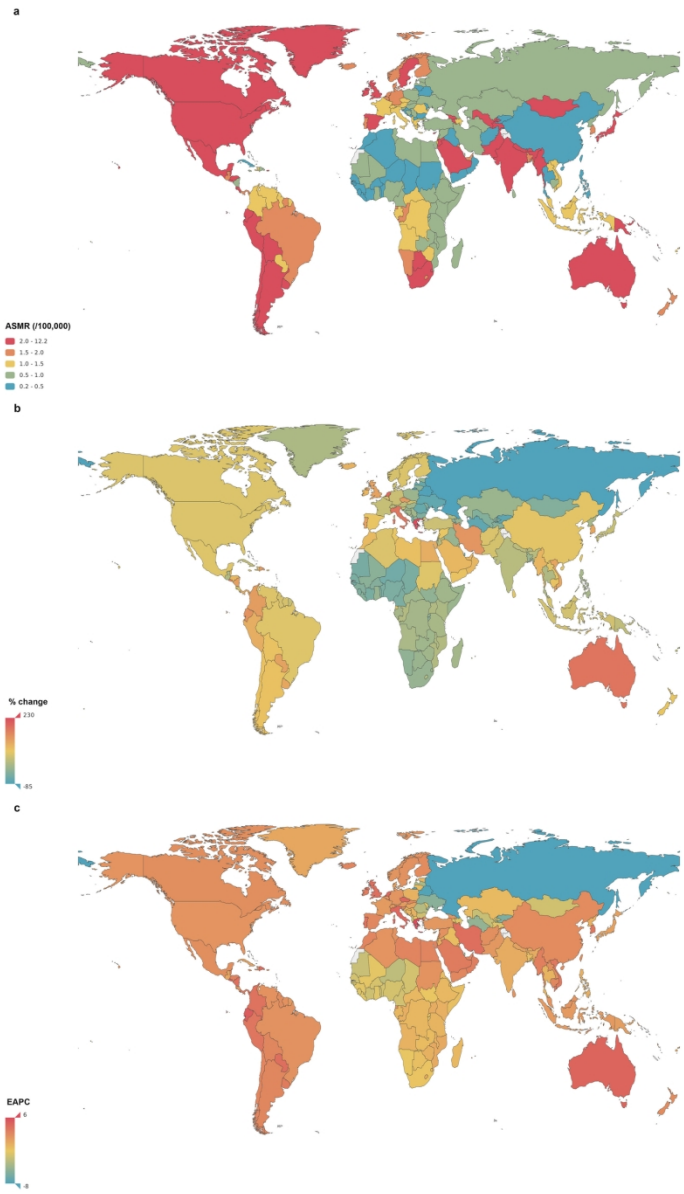

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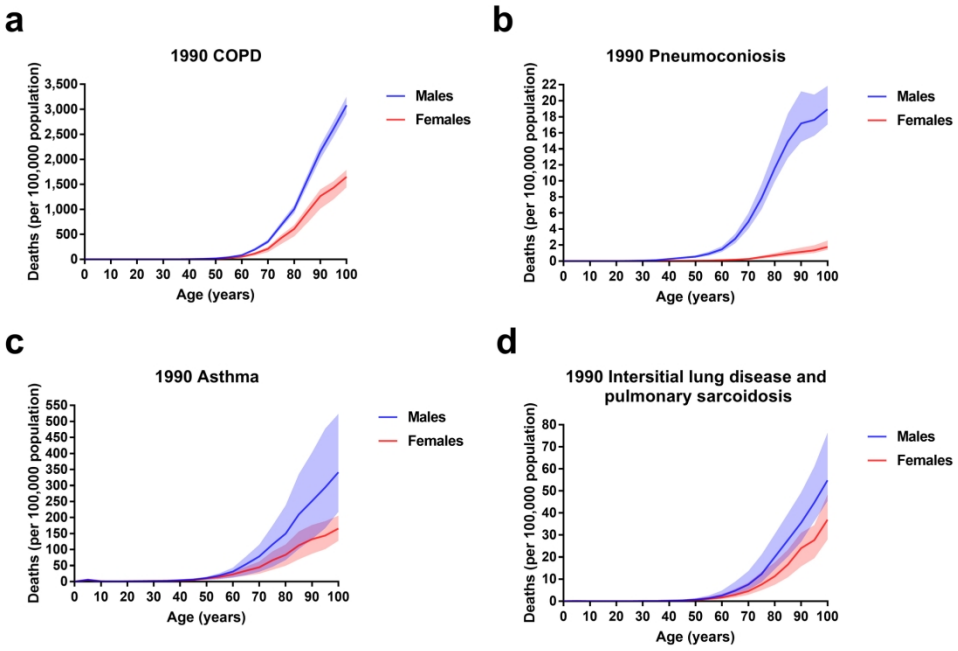

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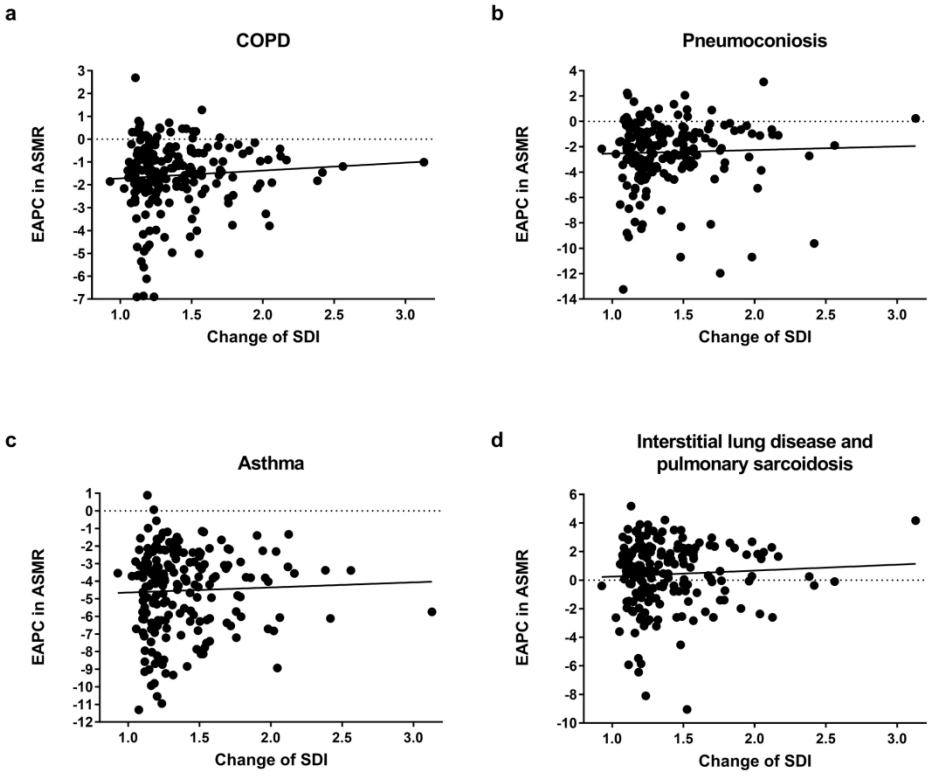

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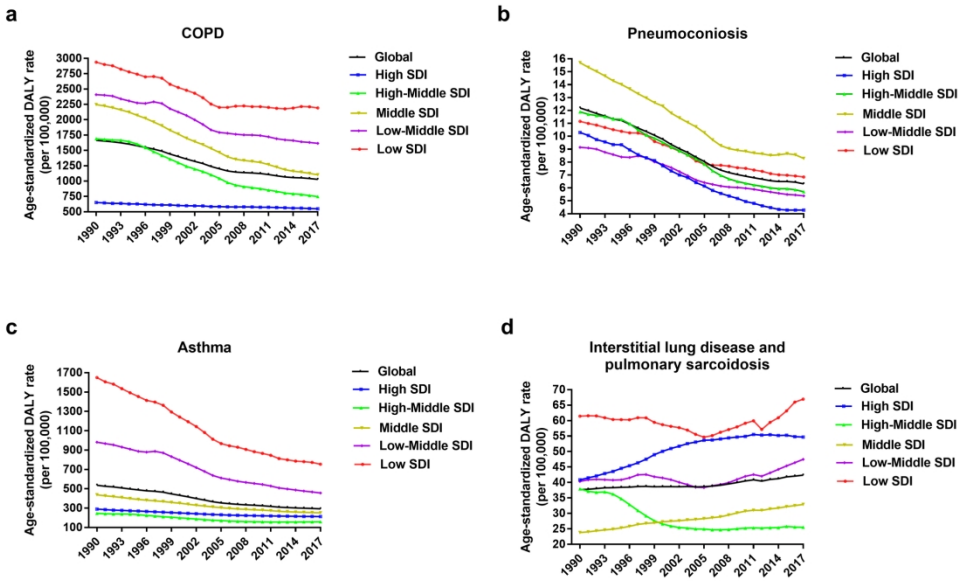

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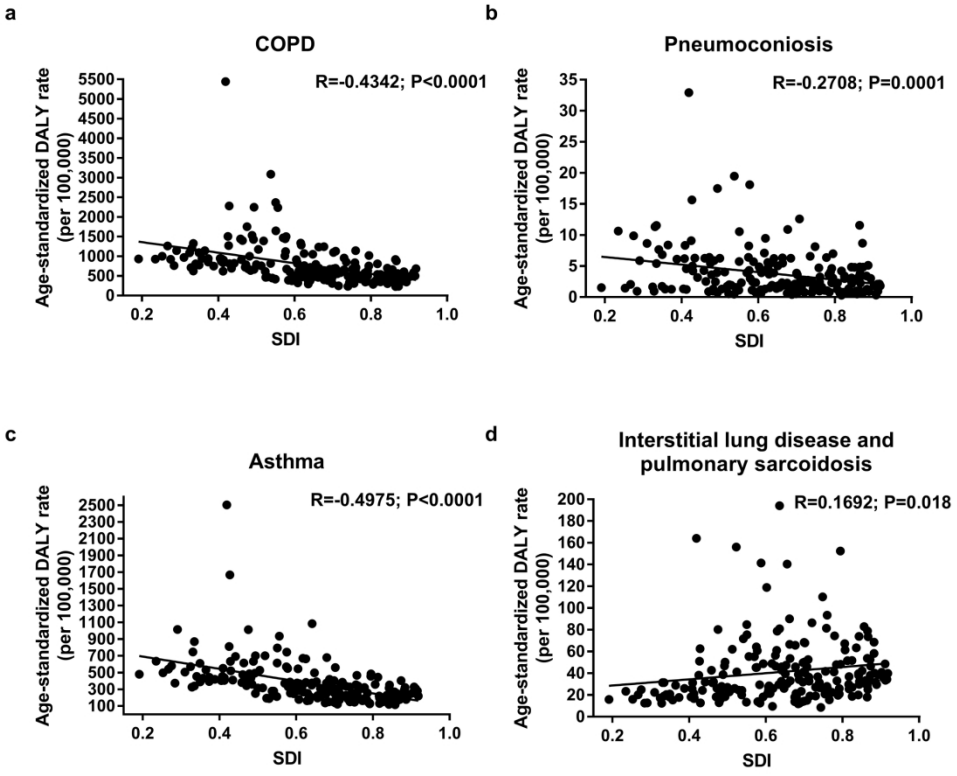

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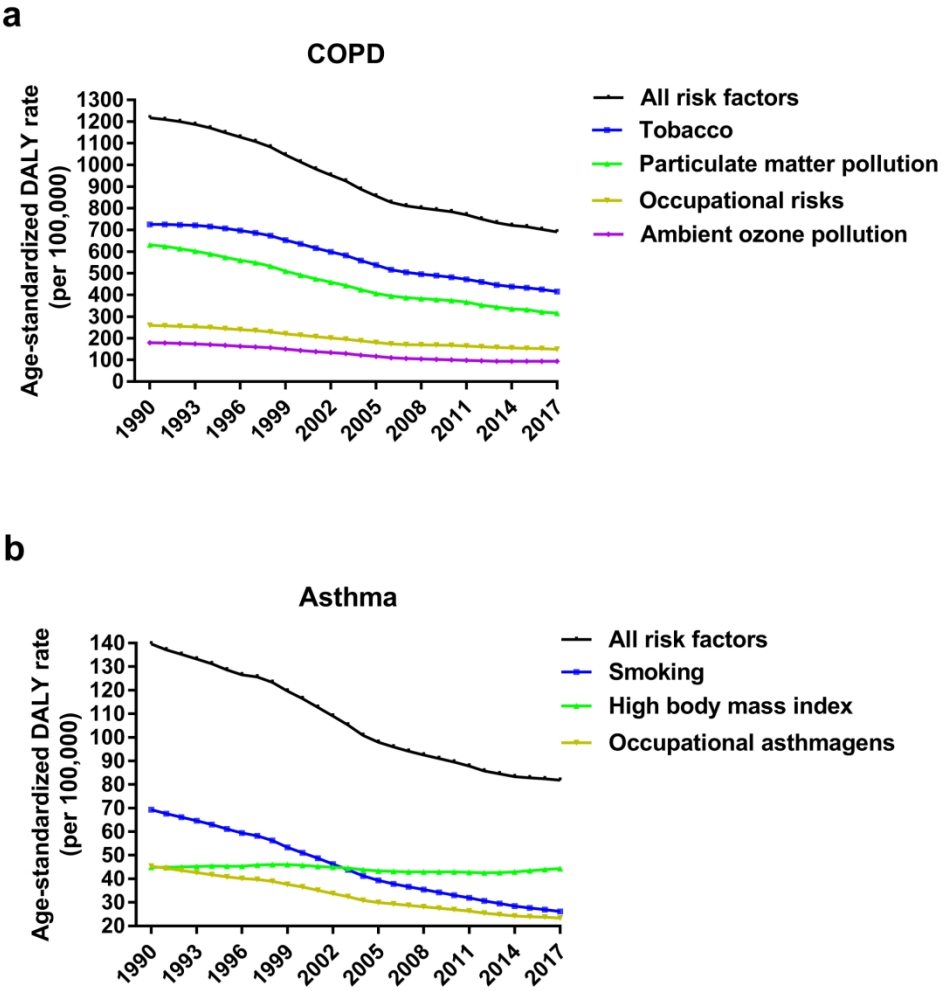

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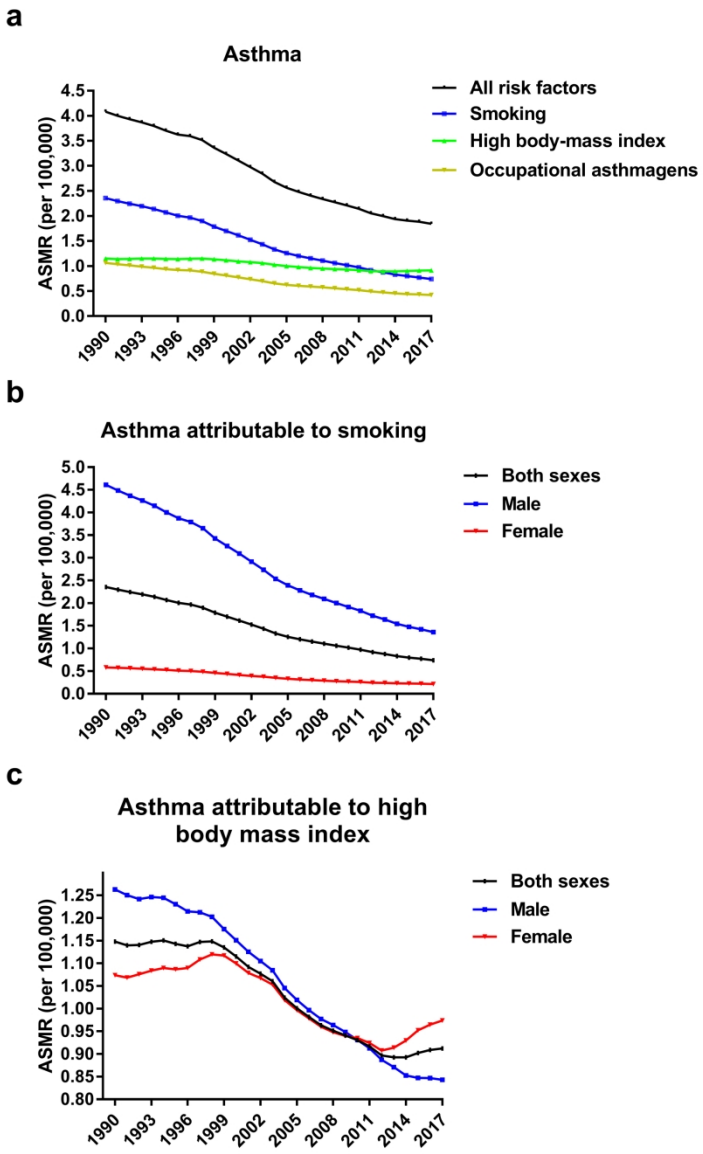

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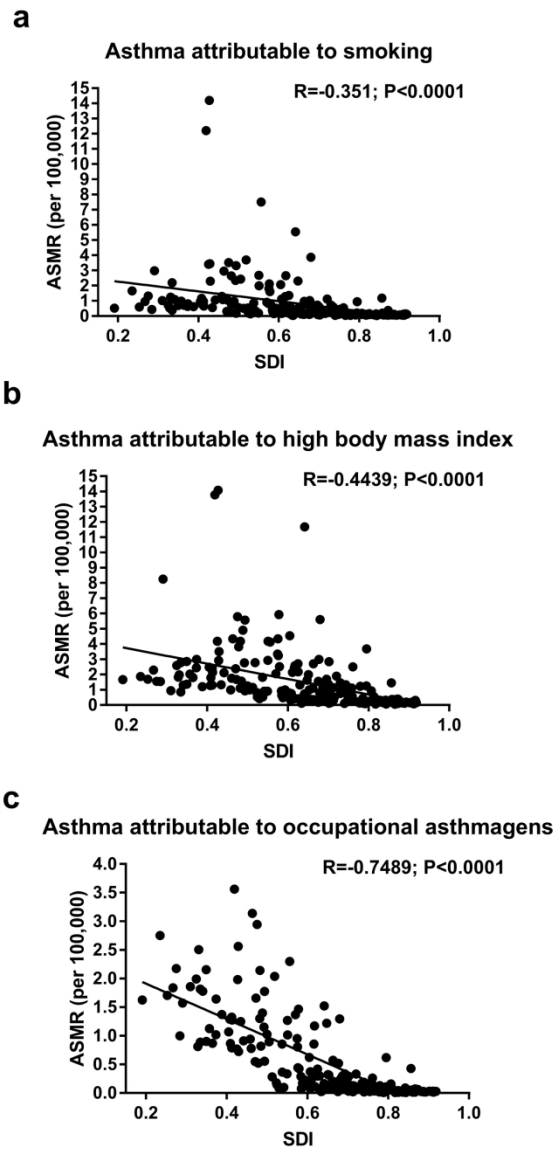

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Supplemental figure legends

Supplemental-Figure 1

The global mortality rate of pneumoconiosis for both sexes in 195 countries and territories.

a. The age-standardized mortality rate (ASMR) of pneumoconiosis for both sexes combinded in 2017.

b. The relative percentage change in the ASMR of pneumoconiosis for both sexes between 1990 and 2017.

c. The estimated annual percentage change (EAPC) in the ASMR of pneumoconiosis for both sexes from 1990 to 2017.

ASMR, age-standardized mortality rate; EAPC, estimated annual percentage change

Supplemental-Figure 2

The global mortality rate of asthma for both sexes in 195 countries and territories.

a. The age-standardized mortality rate (ASMR) of asthma for both sexes combinded in 2017.

b. The relative percentage change in the ASMR of asthma for both sexes between 1990 and 2017.

c. The estimated annual percentage change (EAPC) in the ASMR of asthma for both sexes from 1990 to 2017.

ASMR, age-standardized mortality rate; EAPC, estimated annual percentage change

Supplemental-Figure 3

The global mortality rate of interstitial lung disease and pulmonary sarcoidosis for both sexes in 195 countries and territories.

a. The age-standardized mortality rate (ASMR) of interstitial lung disease and pulmonary sarcoidosis for both sexes combinded in 2017.

b. The relative percentage change in the ASMR of interstitial lung disease and pulmonary sarcoidosis for both sexes between 1990 and 2017.

c. The estimated annual percentage change (EAPC) in the ASMR of interstitial lung

disease and pulmonary sarcoidosis for both sexes from 1990 to 2017.

ASMR, age-standardized mortality rate; EAPC, estimated annual percentage change

Supplemental-Figure 4

The global mortality rates of chronic obstructive pulmonary disease (COPD) (a), pneumoconiosis (b), asthma (c), and interstitial lung disease and pulmonary sarcoidosis (d) by age and sex in 1990.

The shading indicates 95% uncertainty intervals.

COPD, chronic obstructive pulmonary disease.

Supplemental-Figure 5

The correlation between the change in the socio-demographic index (SDI) and estimated annual percentage change (EAPC) in the age-standardized mortality rates (ASMRs) of chronic obstructive pulmonary disease (COPD) (a), pneumoconiosis (b), asthma (c), and interstitial lung disease and pulmonary sarcoidosis (d) from 1990 to 2017.

SDI, socio-demographic index; EAPC, estimated annual percentage change; ASMR, age-standardized mortality rate; COPD, chronic obstructive pulmonary disease.

Supplemental-Figure 6

The age-standardized disability-adjusted life years (DALYs) of chronic obstructive pulmonary disease (COPD) (a), pneumoconiosis (b), asthma (c), and interstitial lung disease and pulmonary sarcoidosis (d) grouped by sociodemographic index (SDI) quintiles from 1990 to 2017.

DALY, disability-adjusted life year; COPD, chronic obstructive pulmonary disease; SDI, socio-demographic index.

Supplemental-Figure 7

The correlation between the sociodemographic index (SDI) and age-standardized disability-adjusted life years (DALYs) of chronic obstructive pulmonary disease

(COPD) (a), pneumoconiosis (b), asthma (c), and interstitial lung disease and pulmonary sarcoidosis (d) in 2017.

SDI, socio-demographic index; DALY, disability-adjusted life year; COPD, chronic obstructive pulmonary disease.

Supplemental-Figure 8

a. The age-standardized disability-adjusted life year (DALY) of chronic obstructive pulmonary disease (COPD) attributable to four kinds of risk factors for both sexes from 1990 to 2017.

b. The age-standardized disability-adjusted life year (DALY) of asthma attributable to three kinds of risk factors for both sexes from 1990 to 2017.

DALY, disability-adjusted life year; COPD, chronic obstructive pulmonary disease.

Supplemental-Figure 9

a. The age-standardized mortality rate (ASMR) of asthma attributable to the three types of risk factors for both sexes from 1990 to 2017.

b. The ASMR of asthma attributable to smoking by sex from 1990 to 2017.

c. The ASMR of asthma attributable to high body mass index by sex from 1990 to 2017.

ASMR, age-standardized mortality rate.

Supplemental-Figure 10

The correlation between the sociodemographic index (SDI) and age-standardized mortality rate (ASMR) of asthma attributable to smoking (a), high body mass index (b), and occupational asthmagens (c) in 2017.

SDI, socio-demographic index; ASMR, age-standardized mortality rate.