Burden of COPD in China and the global from 1990 to 2019: a systematic analysis for the Global Burden of Disease Study 2019

Min Li,1 Hanxiang Chen,1 Na Zhou,2 Ping Zhang,3 Shengnan Duan,1 Taihua Wu,4 Yuanyuan Yi,5 Ni Yuan1,6

ABSTRACT

Objective To investigate the current disease burden of chronic obstructive pulmonary disease (COPD) in China and globally using the Global Burden of Disease (GBD) data in 2019, as well as to analyse the changes in its risk factors, providing a scientific basis for the formulation of a comprehensive prevention and control strategy for COPD in China.

Study design An observational study based on the GBDs.

Methods Based on the GBD 2019 database, we obtained data on incidence, prevalence, mortality, disability-adjusted life years (DALYs) and corresponding age-standardised rates of COPD in China and the global, and analysed and described the changing trends of COPD burden in China and the global from 1990 to 2019.

Results In 2019, the total number of COPD deaths in China was 1.04 (95% uncertainty intervals (95% UI): 0.89–1.27) million cases, the number of patients with COPD was 45.16 (95% UI: 41.13–49.62) million cases, and the number of new cases was 4.0 (95% UI: 3.6–4.4) million cases. DALYs were 74.4 (95% UI: 68.2–80.2) million years. Compared with 1990, the number of new incident cases and the overall prevalence of COPD in China in 2019 increased by 66.20% and 66.76%, respectively, which is lower than the overall global level.

Conclusion From 1990 to 2019, the age-standardized prevalence rate (ASPR), the age-standardized incidence rate (ASIR) and the age-standardized death rate (ASDR) in China and the global all showed a downward trend, and the rate of decline in China was much higher than the overall level of the world, indicating that China has made specific achievements in the prevention and treatment of COPD, but overall the disease burden of COPD is still hefty, and the number of affected individuals is still increasing.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ In recent decades, the disease burden of chronic obstructive pulmonary disease (COPD) has been increasing in both developed and developing countries, as environmental pollution and population ageing worsen globally. The ASPR, ASDR and ASRI in China and the global have shown a downward trend, but the number of patients is still increasing, and the disease burden of COPD cannot be underestimated.

WHAT THIS STUDY ADDS

⇒ This study presents the results of the COPD burden of disease study using the most comprehensive and timely Global Burden of Disease data for 2019. Changes in incidence, prevalence, mortality, and risk factors for COPD in China and globally from 1990 to 2019.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study explores the differences in the burden of COPD globally and in China, provides an empirical basis for understanding the current situation of COPD burden in China and the world and provides a reference for formulating reasonable and effective COPD prevention and control policies.

Exacerbations and comorbidities contribute to the overall severity in individual patients. Due to airflow blockage, the condition is characterized by chronic bronchitis or emphysema, which develops into pulmonary heart disease and respiratory failure. The significant COPD clinical symptoms include a chronic cough, coughing, shortness of breath, respiratory difficulties, wheezing, chest tightness, fatigue and weight loss. Spirometry is the gold standard for diagnosing and evaluating COPD because it is the most accurate, reliable and objective way to measure airflow restriction. The definitions we used for the severity of COPD also followed the GOLD criteria: class 1=mild, ≥80% of normal; class
The third Wednesday of November each year is recognised as World Chronic Obstructive Lung Day by the WHO. Due to rising environmental pollution and an ageing population, the disease burden of COPD is growing globally in both developed and developing nations. Between 1990 and 2017, the global incidence of COPD increased by 5.9%. The previous literature has also reported nearly 3 million deaths attributed to this disease, accounting for approximately 5.4% of all deaths. According to estimates from the WHO, China has the highest COPD mortality rate of any nation. COPD ranks third among the world’s leading causes of death, accounting for 6% of all deaths, behind only iron deficiency, heart disease and stroke. This demonstrates the significance of COPD as a public health issue. The burden of COPD in China will climb further in the future, making it a high-profile chronic disease prevention and treatment concern; academic projections suggest that the number of new COPD-related cases and deaths in China will increase approximately 1.5 times over the next 25 years, this is consistent with the conclusions reached in this paper.

Due to disparities in socioeconomic development and exposure to risk factors across regions, the prevalence of COPD reported by various geographic areas also varied significantly. The Global Burden of Disease (GBD) 2019 database lists eight specific risk factors that are thought to increase the chance of mortality in patients with COPD, with smoking, ambient particulate pollution and occupational particulate matter, gases and smoke ranking as the top three risk factors in 2019. In the available literature, each risk factor is defined and quantified. Although there is a large body of evidence on the epidemiology of COPD, its impact on the burden of the disease is limited by insufficient data and scattered data. Therefore, this study uses detailed national-level morbidity and mortality data to make accurate estimates of the prevalence of COPD, provide a realistic basis for the disease burden of COPD and explore the disease burden and risk factors for COPD globally and in China. This purpose is to provide an empirical basis for understanding the current burden of COPD in China and even the world, improve the public’s understanding of COPD, reduce the burden of COPD and provide a reference for formulating reasonable and effective COPD prevention and control policies.

**MATERIALS AND METHODS**

**Data sources**

Data sources for this study were published on the website of the Institute for Health Metrics and Evaluation (IHME) (http://ghdx.healthdata.org/), the world’s most extensive and credible database on disease burden, IHME of the University of Washington, aims to assess the burden of disease for 315 diseases, injuries and risk factors in 195 countries and territories around the world, and regularly publishes data on morbidity, mortality and disability-adjusted life expectancy, by country, year, sex, cause factors and age, and covers annual morbidity, death and disability-adjusted life years (DALYs) from 1 January 1990 to 31 December 2019 and risk factors. The GBD estimation process is based on identifying multiple relevant data sources for each disease or injury, including censuses, household surveys, civil registration and vital statistics, disease registers, health service use, air pollution monitoring, satellite imaging, disease notifications and other sources. These data should be downloaded from the Global Health Data Exchange website (http://ghdx.healthdata.org/ Global Database Tool) on request. This study extracted and analysed data on the burden of disease and risk factors for COPD in China and globally from 1990 to 2019.

**Statistical analysis**

Considering the original data source, data manipulation, measurement error and uncertainty in model selection, this database was analysed, modelled and estimated using the IHME Bayesian regression tool DisMod-MR V2.1 for indicators such as incidence, prevalence, mortality, DALYs, which were standardised for the world population and reported as age-standardised incidence, prevalence, mortality and DALY rates per 100,000 population. The data saved for this study were cleaned and collated, then tabulated and plotted using Excel and Origin 2022. All estimates were produced as 95% uncertainty intervals (95% UI), which has been used in the GLOBOCAN 2018 database to access incidence and mortality from 36 cancers and for all cancers combined for the year 2018, including all uncertainty factors caused by measurement error, bias and modelling, with the 95% UI taken from the 25th and 975th percentiles of the 1000th sample. As the GBD database has age-standardised, the data and given the 95% UI it can be directly analysed statistically and plotted.

**Metrics selection and interpretation**

In this study, incidence, prevalence, mortality and corresponding age-standardised rates (ASR) were used to assess the prevalence of COPD. As defined in the GBD 2019 study, the incidence is the proportion of new cases of COPD per 100,000 population; prevalence is the proportion of new and existing COPD cases per 100,000 population; mortality is the proportion of deaths per 100,000 population; DALYs are the proportion of disability life years and death life years per 100,000 population that approximately reflect the gap between the current health status of the population and the desired status. This study also quantifies the burden of disease using years lived with disability (YLD), years of life lost (YLL) and DALY, where 

\[YLL = \sum (N \times L), \quad N \text{ represents the number of deaths from disease, and } L \text{ represents the difference between the age at death and the life expectancy of the standard life table death age group}; \quad YLD = P \times DW, \quad P \text{ represents the} \]

2=moderate, 50%–79% of normal; class 3 and 4=severe, <50% of normal. The third Wednesday of November each year is recognised as World Chronic Obstructive Lung Day by the WHO. Due to rising environmental pollution and an ageing population, the disease burden of COPD is growing globally in both developed and developing nations. Between 1990 and 2017, the global incidence of COPD increased by 5.9%. The previous literature has also reported nearly 3 million deaths attributed to this disease, accounting for approximately 5.4% of all deaths. According to estimates from the WHO, China has the highest COPD mortality rate of any nation. COPD ranks third among the world’s leading causes of death, accounting for 6% of all deaths, behind only iron deficiency, heart disease and stroke. This demonstrates the significance of COPD as a public health issue. The burden of COPD in China will climb further in the future, making it a high-profile chronic disease prevention and treatment concern; academic projections suggest that the number of new COPD-related cases and deaths in China will increase approximately 1.5 times over the next 25 years, this is consistent with the conclusions reached in this paper.

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number of people with a disease, and DW represents disability weight; DALY is the sum of YLD and YLL.

RESULT

Global and China COPD epidemic status in 2019

In 2019, the number of deaths due to COPD global was as high as 3.3 (95% UI: 2.9–3.6) million cases, with ASDR of 42.5 (95% UI: 37.6–46.3) /100 000, of which the number of prevalent cases reached 212.3 (95% UI: 200.4–225.1) million cases, and the number of new patients with COPD 16.2 (95% UI: 15.2–17.2) million cases. The ASPR and ASIR were 2638.2 (95% UI: 2492.2–2796.1) /100 000 and 200.5 (95% UI: 188.6–212.6) /100 000, respectively, (table 1).

In 2019, the number of patients with COPD in China was 1.0 (95% UI: 0.89–1.3) million cases, of which the number of new patients with COPD was 4.0 (95% UI: 3.7–4.4) million cases, with ASPR and ASIR were 2404.4 (95% UI: 2195.9–2636.3) /100 000 and 205.9 (95% UI: 188.4–223.6) /100 000, respectively. In 2019, the number of deaths due to COPD in China reached 1.04 (95% UI: 0.89–1.27) million cases and the ASDR was 65.2 (95% UI: 55.5–80.09) /100 000 (table 1).

Epidemic situation of COPD among different age groups in China and the global in 2019

The effect of age on the morbidity of COPD in China shows a trend of increasing before decreasing, and the older and younger ages both have less effect on the morbidity. In 2019, China, as well as globally, had the highest number of COPD cases in the age group of 70–74 years, which reached 6.8 (95% UI: 5.8–8.0) million cases.
in China. With increasing age, the number of COPD cases in China in 2019 showed a trend of increasing and then decreasing, while the prevalence gradually increased, in line with the global change. The overall incidence of COPD in China in 2019 shows a trend of increasing with age, and the largest number of new cases is in the age group of 65–69 years, which has reached 0.66 (95% UI: 0.48–0.83) million cases, in addition, the incidence of COPD in China is gradually higher than the global incidence level.

The number of deaths due to COPD in the Chinese population in 2019 shows an overall trend of increasing and then decreasing, with mortality due to COPD in the Chinese population showing a gradual increase with age. The overall number of deaths in the population aged 80–84 years reached a peak, after which the overall number of deaths in the population gradually decreased, in line with the change in global mortality, with the number of deaths due to COPD in China being much lower than the global level, but the mortality rate for those aged 70 years and above being much higher than the global level (figures 1–3).

**Trends in the prevalence of COPD in China and the global from 1990 to 2019**

The number of global deaths due to COPD in 2019 was 3.3 (95% UI: 2.9–3.6) million cases, an increase of approximately 760,000 compared with 2.5 (95% UI: 2.1–2.7) million deaths in 1990, and ASDR decreased from 73 (95% UI: 61.5–78.8)/100,000 to 42.5 (95% UI: 37.6–46.3)/100,000, a decrease of 41.7%. The number of prevalent cases also increased from 114.9 (95% UI: 109.4–120.7) million cases in 1990 to 212.3 (95% UI: 200.4–225.1) million cases in 2019, an almost 97 million increase. The ASPR decreased from 2890.89 (95% UI: 2743.25–3038.09)/100,000 in 2019 to 2638.20 (95% UI: 2492.17–2796.13)/100,000 in 2019, a decrease of 8.7%. According to statistics, the number of new COPD cases worldwide increased from 8.72 (95% UI: 8.2–9.2) million cases in 1990 to 16.2 (95%: 15.2–17.2) million cases in 2019, an increase of about 7.5 million cases. In 1990, the ASIR of COPD was 216.48 (95% UI: 204.56–227.33)/100,000 and it dropped to 200.49 (95% UI: 188.63–212.57) in 2019, a decrease of 7.4%. This shows that there is a global downward trend in ASDR, ASPR and ASIR.

From the GBD database, the number of new COPD cases in China increased from 2.4 (95% UI: 2.2–2.5) million cases in 1990 to 4.0 (95% UI: 3.6–4.4) million cases in 2019, an increase of about 1.58 million cases. However, the ASIR is on a downward trend, from 288.05 (95% UI: 271.18–302.45)/100,000 in 1990 to 205.89 (95% UI: 188.41–223.62)/100,000 in 2019, a decrease of 28.5%. The number of global deaths due to COPD in 2019 was 1.0 (95% UI: 0.89–1.3) million deaths, a decrease of about 200,000 from 1.2 (95% UI: 0.91–1.4) million deaths in 1990. The ASDR decreased by 70.1% from 217.94 (95% UI: 163.27–242.01)/100,000 in 1990 to 65.20 (95% UI: 55.51–80.09)/100,000 in 2019. The number of cases increased from 27.8 (95% UI: 26.2–29.4) million in 1990 to 45.2 (95% UI: 41.1–49.6) million in 2019, an increase of about 17 million. The ASPR decreased from 3300.93 (95% UI: 3104.84–3496.05) per 100,000 in 1990 to 2404.42 (95% UI: 2195.91–2636.26) in 2019, a decrease of 27.16%. China’s ASIR, ASDR and ASPR are broadly in line with the global trend, all showing a downward trend (figures 4–6).

**Trends in the burden of COPD in China and the global from 1990 to 2019**

Globally, DALYs for COPD increased from 59.2 (95% UI: 51.2–63.6) million years in 1990 to 74.4 (95% UI: 68.3–80.2) million years in 2019, an increase of 25.64%. However, ASR–DALYs show a decreasing trend, from 1537.71 (95% UI: 1330.68–1647.46)/100,000 years in
1990 to 926.07 (95% UI: 848.76–997.67)/100000 years in 2019. Compared with 1990, the global ASR–YLD and ASR–YLL decreased by 4.9% and 46.8%, respectively, in 2019.

The DALYs for COPD in China in 2019 is 19.9 (95% UI: 17.4–23.7) million years, compared with DALYs of 26.1 (95% UI: 19.6–29.4) million years in 1990, a decrease of 23.72%, which is opposite to the overall global DALYs. The ASR–DALYs in China from 1990 to 2019 also show a decreasing trend, with 3611.81 (95% UI: 2710.98–4026.49)/100000 in 1990 and 1102.77 (95% UI: 962.93–1309.03)/100000 in 2019. Compared with 1990, the global ASR–YLD and ASR–YLL decreased by 27.2% and 73.7%, respectively, in 2019 (table 2, figures 7–9).

**Trends in COPD risk factors in China and the global from 1990 to 2019**

Analysis of GBD risk factor data from 1990 to 2019 reveals that the main risk factors associated with COPD deaths include: smoking, ambient particulate matter, occupational particulate matter, low temperature, secondhand smoke, ambient ozone pollution, household air pollution due to solid fuels and high temperature. In 2019, the COPD deaths caused by the above factors in the Chinese population accounted for 50.70% (95% UI:4.88%–45.66%), 25.44% (95% UI: 0.85%–20.76%), and 16.73% (95% UI: 9.56%–14.42%), 11.89% (95% UI:7.32%–6.36%), 9.07% (95% UI:4.22%–4.16%).

Compared with 1990, COPD deaths due to smoking, ambient particulate matter, occupational particulate matter, low temperature, exposure to secondhand smoke, ambient ozone pollution, household air pollution due to solid fuels and high temperature increased as a proportion of total COPD deaths in 2019 by 11.1%, 63.74%, −0.48%, −2.78%, −9.58%, −4.97%, −81.69% and 35.37%, respectively. The figure shows that from 1990 to 2019, the number of COPD deaths caused by smoking in China fluctuated slightly but still showed an upward trend; household air pollution due to solid fuels showed a rapidly decreasing trend; ambient particulate matter showed a general upward trend, reaching a peak in 2015 and showing a slight decrease thereafter; ozone pollution shows a fluctuating to an increasing trend, reaching a peak in 2008 and then slowly ambient ozone pollution follows a fluctuating upward trend, peaking in 2008 and then slowly declining, before starting to rise again in 2014 and peaking in 2017, with a declining trend thereafter; occupational particulate matter exposure, low-temperature environments, and secondhand smoke exposure show a more moderate overall trend (figures 10 and 11).

**DISCUSSION**

This study analysed the global COPD incidence, prevalence, mortality and DALYs metrics and the corresponding annual standardised rates between 1990 and 2019 by accessing data from the GBD database and comparing them with China to provide a more comprehensive assessment of the disease burden of COPD in China. The findings of this study revealed that the ASDR, ASIR and ASR–DALYs of COPD in China in 2019 were all higher than the global average. This may be related to the cumulative effect of risk factors such as China’s recent rapid socioeconomic development, increasing industrialisation and urbanisation, rising elderly population and unhealthy lifestyles. However, the increase in the total number of patients with COPD and the number of new cases in China in 2019 was lower than the global average compared with 1990. This suggests that China is making a positive contribution to the prevention and management of COPD. The prevalence of population censuses and evolving medical diagnostic and treatment modalities are likely to be major factors in the declining trend of ASDR in China and globally. For the past three decades, COPD, a chronic lung disease associated with smoking, has mainly affected people aged 50–89 years, but in recent years is increasingly affecting younger people and we believe there are several reasons why the number of people with COPD will continue to increase and become younger. First, in addition to lifestyle factors such as smoking, diet is considered a modifiable risk factor for the onset and progression of chronic disease. Currently, there has been a dramatic change in the composition of people’s diets, with a reduction in fruit, vegetables, whole grains and fish and an increase in the consumption of processed and refined foods, and this change in dietary habits may indirectly lead to adverse environmental exposures or genetic susceptibility to harmful effects on the lungs. There are also a number of factors that may contribute to impaired lung development in adolescents, which in turn may lead to the causes of COPD, including recurrent respiratory infections, late nights and secondhand smoke and early age of smoking.
Table 2  Comparison of global and Chinese burden of disease in 1990 and 2019

<table>
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<tr>
<th></th>
<th>DALY (year) (95% UI)</th>
<th>ASR–DALYs (/100 000) (95% UI)</th>
<th>YLL (year) (95% UI)</th>
<th>ASR–YLL (/100 000) (95% UI)</th>
<th>YLD (year) (95% UI)</th>
<th>ASR–YLD (/100 000) (95% UI)</th>
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<tbody>
<tr>
<td>Global</td>
<td>1990</td>
<td>59 241 939.23 (51 208 418.89–63 591 5840.43)</td>
<td>1537.72 (1330.69–1647.45)</td>
<td>48 769 204.02 (40 770 893.13–52 860 9440.36)</td>
<td>1279.92 (1073.46–1384.67)</td>
<td>10 472 735.20 (8 682 193.65–11 830 6790.95)</td>
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<td></td>
<td>2019</td>
<td>74 432 366.82 (68 204 126.93–80 193 3470.45)</td>
<td>926.07 (848.76–997.67)</td>
<td>54 594 898.10 (48 711 468.20–59 513 3660.66)</td>
<td>680.80 (606.41–741.65)</td>
<td>19 837 468.73 (16 596 489.96–22 441 7270.20)</td>
</tr>
<tr>
<td></td>
<td>Percentage change between 1990 and 2019</td>
<td>25.64%</td>
<td>–39.78%</td>
<td>11.95%</td>
<td>–46.81%</td>
<td>89.42%</td>
</tr>
<tr>
<td>China</td>
<td>1990</td>
<td>26 118 524.59 (19 585 434.33–29 356 3500.30)</td>
<td>3611.81 (2710.97–4026.48)</td>
<td>23 327 872.57 (16 754 572.95–26 465 895.08)</td>
<td>3281.48 (2393.73–3687.54)</td>
<td>27 906 520.01 (23 097 707.27–32 189 980.84)</td>
</tr>
<tr>
<td></td>
<td>2019</td>
<td>19 922 947.56 (17 355 633.27–23 704 9730.53)</td>
<td>1102.77 (962.93–1309.03)</td>
<td>15 411 451.84 (13 078 943.67–18 937 549.59)</td>
<td>862.37 (736.41–1053.64)</td>
<td>45 114 957.11 (37 044 830.01–52 658 990.99)</td>
</tr>
<tr>
<td></td>
<td>Percentage change between 1990 and 2019</td>
<td>–23.72%</td>
<td>–69.47%</td>
<td>–33.94%</td>
<td>–73.72%</td>
<td>61.66%</td>
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ASR, age-standardised rate; ASR-DALYs, age-standardized disability adjusted life years; DALY, disability-adjusted life year; DALYs, disability adjusted life years; YLD, years lived with disability; YLL, years of life lost.
Despite its high mortality and morbidity, COPD is both curable (by reducing risk factor exposure) and preventable (by reducing COPD symptoms and exacerbations). Therefore, the burden arising from early to late disease progression should be reduced through increased awareness of prevention. They are considering that China has the largest proportion of current smokers in the world and the significant impact of smoking on COPD mortality, reducing tobacco use may be the most effective and practical way to avoid COPD in China. With the introduction of tobacco control regulations in China, the future is likely to see more accurate management of the smoking population to mitigate the harm caused by smoking, as well as greater attention to the problem of COPD in non-smokers. Occupational dust (silica, coal dust, cotton dust, etc) is also the main cause of COPD, and publicity and education should be strengthened to improve dust prevention awareness and protection knowledge. The employer shall establish and improve various rules and regulations for dust prevention to

Figure 7  Trends of ASR–DALYs in China and global chronic obstructive pulmonary disease from 1990 to 2019. ASR, age-standardised rate; DALY, disability-adjusted life year.

Figure 8  Trends of ASR–YLD in China and global chronic obstructive pulmonary disease from 1990 to 2019. ASR, age-standardised rate; YLD, years lived with disability.
ensure the normal operation of dust prevention facilities and that the dust concentration in the workplace air meets the requirements of national standard limits. Socioeconomic status and the incidence of COPD are also closely related, and people with low socioeconomic status have a greater probability of COPD, which may be related to poor nutrition and overcrowding, so relevant government departments should pay more attention to people with lower economic status. The relevant government departments can play a preventive and protective role against COPD by strengthening health education on balanced diets, such as posting posters on balanced diets in public places, improving the health of growing adolescents by increasing exercise and diet, keeping adolescents away from tobacco through tobacco education, and minimising recurrent respiratory infections among

Figure 9  Trends of ASR–YLL in China and global chronic obstructive pulmonary disease from 1990 to 2019. ASR, age-standardised rate; YLL, years of life lost.

Figure 10  Changes of risk factors for chronic obstructive pulmonary disease in China from 1990 to 2019. ASR, age-standardised rate.
The study also shows that the impact of indoor particulate matter combustion on COPD is decreasing year by year, which may be because, with economic development, the use of solid fuels such as indoor fires has changed, and the use of alternative clean fuels has increased, kitchen ventilation measures have improved, and China and around the world should develop in-depth plans to reduce atmospheric particulate matter.\(^{18,19}\)

As China’s economy has grown in recent years, basic medical insurance for urban employees and residents has been introduced. This insurance might now cover at least 90% of the Chinese population,\(^ {20}\) making therapy more accessible to more Chinese patients with COPD. The Chinese government has adopted pertinent regulations to encourage the prevention and treatment of chronic respiratory disorders and is also paying more attention to these conditions, particularly COPD. However, primary and secondary prevention are the most effective measures for chronic diseases such as COPD. Currently, China does not pay enough attention to public health, so the government and other departments should also increase funding and strengthen public health awareness. Therefore, it is also possible to improve the effectiveness of slow obstructive pulmonary screening in China by optimising the screening methods, reducing the incidence of risk factors and reducing the burden of disease caused by them by promoting early diagnosis and treatment.

LIMITATIONS
All data in this paper are from the GBD 2019 database, but the accuracy and reliability of the GBD estimate largely depend on the quality and quantity of the data used in the study, which is mainly derived from administrative registers, population censuses, surveillance statistics, disease registers, epidemiological surveillance, literature reports, etc, as the basis for mathematical modelling, and then used to calculate the corresponding indicators, and is not strictly designed statistics for large-scale COPD surveys, so it may differ from reality. The rate of misdiagnosis of COPD should also be taken into account, and as GBD 2019 does not provide results by province, regional differences in China need to be studied in depth, so further analysis of the burden of COPD in urban and rural China is not possible.

Contributors ML and HC contributed the same to the text, and NY and YY were the corresponding authors. ML, NZ and HC jointly completed the manuscript writing. SD and PZ processed the data. NY, YY and TW conceived the research guidance, and all authors reviewed the manuscript. NY has full access to all data in the study and is ultimately responsible for the decision to submit for publication.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. The data sources of this study are all published on the IHME official website (http://ghdx.healthdata.org/); data are available in a public, open access repository. All data are publicly available. Data are available on request.

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