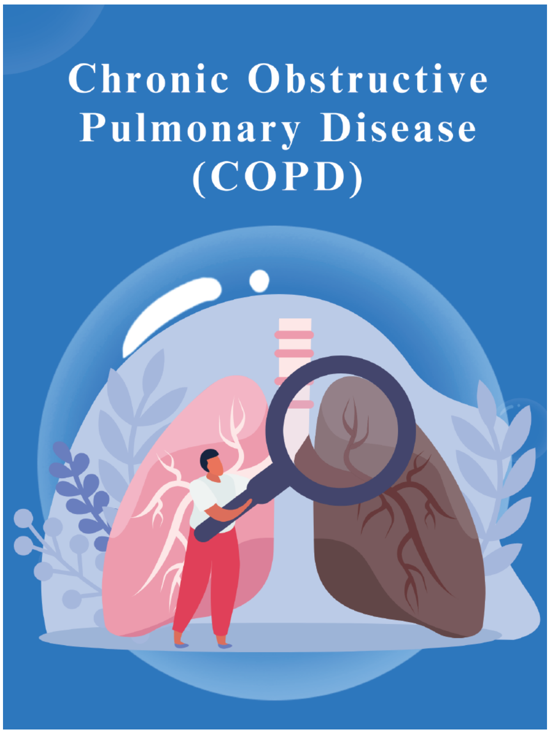
ISSN 2096-7071 (Print)
ISSN 2096-3101 (Online)
CN 10-1629/R1

CHINA CDC WEEKLY

Vol. 6 No. 43 Oct. 25, 2024

CCDC weekly

中国疾病预防控制中心周报



COPD ISSUE

ISSN 2096-7071
9 772096 707248 43

Editorial Board

Editor-in-Chief Hongbing Shen
Founding Editor George F. Gao
Deputy Editor-in-Chief Liming Li Gabriel M Leung Zijian Feng
Executive Editor Chihong Zhao
Members of the Editorial Board
Rui Chen
Wen Chen
Xi Chen (USA)
Zhuo Chen (USA)
Gangqiang Ding
Xiaoping Dong
Pei Gao
Mengjie Han
Yuantao Hao
Na He
Yuping He
Guoqing Hu
Zhibin Hu
Yueqin Huang
Na Jia
Weihua Jia
Zhongwei Jia
Guangfu Jin
Xi Jin
Biao Kan
Haidong Kan
Ni Li
Qun Li
Ying Li
Zhenjun Li
Min Liu
Qiyong Liu
Xiangfeng Lu
Jun Lyu
Huilai Ma
Jiaqi Ma
Chen Mao
Xiaoping Miao
Ron Moolenaar (USA)
Daxin Ni
An Pan
Lance Rodewald (USA)
William W. Schluter (USA)
Yiming Shao
Xiaoming Shi
Yuelong Shu
RJ Simonds (USA)
Xuemei Su
Chengye Sun
Quanfu Sun
Xin Sun
Feng Tan
Jinling Tang
Huaqing Wang
Hui Wang
Linhong Wang
Tong Wang
Guizhen Wu
Jing Wu
Xifeng Wu (USA)
Yongning Wu
Min Xia
Ningshao Xia
Yankai Xia
Lin Xiao
Wenbo Xu
Hongyan Yao
Zundong Yin
Dianke Yu
Hongjie Yu
Shicheng Yu
Ben Zhang
Jun Zhang
Liubo Zhang
Wenhua Zhao
Yanlin Zhao
Xiaoying Zheng
Maigeng Zhou
Xiaonong Zhou
Guihua Zhuang

Advisory Board

Director of the Advisory Board Jiang Lu
Vice-Director of the Advisory Board Yu Wang Jianjun Liu Jun Yan
Members of the Advisory Board
Chen Fu
Gauden Galea (Malta)
Dongfeng Gu
Qing Gu
Yan Guo
Ailan Li
Jiafa Liu
Peilong Liu
Yuanli Liu
Kai Lu
Roberta Ness (USA)
Guang Ning
Minghui Ren
Chen Wang
Hua Wang
Kean Wang
Xiaoqi Wang
Zijun Wang
Fan Wu
Xianping Wu
Jingjing Xi
Jianguo Xu
Gonghuan Yang
Tilahun Yilma (USA)
Guang Zeng
Xiaopeng Zeng
Yonghui Zhang
Bin Zou

Editorial Office

Directing Editor Chihong Zhao
Managing Editors Yu Chen
Senior Scientific Editors Daxin Ni Ning Wang Wenwu Yin Shicheng Yu Jianzhong Zhang Qian Zhu
Scientific Editors
Weihong Chen
Tao Jiang
Xudong Li
Nankun Liu
Liwei Shi
Liuying Tang
Meng Wang
Zhihui Wang
Qi Yang
Qing Yue
Lijie Zhang
Ying Zhang

Cover Image: adapted from Canva, https://www.canva.cn/.
This week's issue was organized by Guest Editor Canqing Yu.

Vital Surveillances

Chronic Obstructive Pulmonary Disease-Associated Mortality — China, 2014–2021

Zifang Zhou[1]; Lijun Wang[1]; Maigeng Zhou[1]; Peng Yin[1,#]

ABSTRACT

Introduction: China faces a growing burden of chronic obstructive pulmonary disease (COPD). Previous mortality estimations were primarily based on the underlying cause of death. This study analyzed COPD-associated death and its comorbidities using all COPD cases listed on the chain of events on death certificates.

Methods: A retrospective analysis of the National Mortality Surveillance System (NMSS) was conducted to estimate COPD-associated mortality from 2014 to 2021. Age-standardized mortality rates (ASMRs) were calculated stratified by sex, region, and residence. Joinpoint regression was used to estimate the average annual percentage change (AAPC) during the study period.

Results: From 2014 to 2021, the ASMR of COPD decreased from 91.85 to 45.90 per 100,000 population. Significant but uneven decreases in COPD mortality were observed across gender [females: AAPC: −11.2%, 95% confidence interval (*CI*): −11.9 to −10.4%; males: AAPC: −8.0%, 95% *CI*: −9.2 to −6.8%], regions (eastern: AAPC: −10.7%, 95% *CI*: −11.5 to −9.9%; central: AAPC: −9.9%, 95% *CI*: −10.9 to −8.9%; western: AAPC: −7.7%, 95% *CI*: −10.6 to −4.7%), and residential areas (urban: AAPC: −10.9%, 95% *CI*: −12.3 to −9.5%; rural: AAPC: −8.3%, 95% *CI*: −9.1 to −7.4%). Other than COPD, cardiovascular diseases and respiratory conditions were the major underlying causes of death in COPD-associated mortality.

Conclusions: COPD is a significant comorbidity of other disorders in China. Although COPD-associated mortality substantially decreased from 2014 to 2021, the burden remained high in underdeveloped regions.

Chronic obstructive pulmonary disease (COPD) is a leading cause of death globally, resulting in severe economic and public health consequences (*1*–*2*). As a heterogeneous condition, COPD is caused primarily by exposure to smoke and air pollution, in combination with genetic and social factors, and often increases the risk of other chronic events (*3*–*4*). Older adults are the most susceptible population due to age-related decline in lung function (*3*). Given the accelerating pace of aging and the large number of active smokers in China (*5*–*6*), a substantial COPD burden is unsurprising (*7*–*8*).

Considering the growing burden of COPD in China, assessing the latest mortality patterns associated with this disease is crucial for refining management and prevention strategies. Additionally, because COPD frequently coexists with other chronic conditions, understanding its comorbidity patterns is essential. However, most mortality estimates rely on the underlying cause of death, which may not accurately reflect the full scope of COPD-associated mortality. Therefore, this study aimed to investigate the regional distribution and temporal trends of COPD-associated mortality in China between 2014 and 2021. We utilized nationally representative data from the National Mortality Surveillance System (NMSS), including all COPD cases on death certificates listed on the chain of events.

METHODS

This study was a retrospective analysis based on the NMSS, a system initiated in 1978 that gradually expanded nationwide. The NMSS finally covered 605 surveillance points in 31 provincial-level administrative divisions (PLADs), including in-hospital and outside-hospital deaths. It encompasses 323.8 million people, accounting for 24.3% of China's population (*9*), with national and provincial representativeness. With a standardized workflow and strict quality control procedures, the NMSS ensures the completeness and accuracy of death records, forming the basis for official mortality statistics. Detailed information on the NMSS is provided elsewhere (*9*).

COPD-associated mortality was defined as deaths with COPD certified as a cause of death anywhere on the chain of events in parts 1 and 2. COPD was defined using codes J40–J44 from the International Classification of Diseases, 10th edition (ICD-10). In addition to COPD, other major causes of death, including other respiratory events and cardiovascular diseases (CVDs), were included in the analysis.

COPD-associated deaths, stratified by sex, region, and residence, were derived from the NMSS from 2014 to 2021. The proportion of the underlying cause of death in COPD-associated mortality and the contributory cause of death with COPD as the underlying cause of death were calculated. The under-reporting adjustment was applied to estimate COPD-associated mortality (*10*). The ASMR was calculated using the direct standardization method using the 2020 China census as the reference population (*10*). The temporal trend of COPD-associated mortality from 2014 to 2021 was described by the AAPC with a 95% confidence interval (*CI*), estimated by a joinpoint regression model (Joinpoint Regression Program, version 5.0.2; National Cancer Institute, Rockville, MD, USA). Statistical analyses were performed using SAS version 9.4 (SAS Institute; Cary, NC, USA) and R (version 4.1.3; R Foundation for Statistical Computing, Vienna, Austria). All tests were two-sided, and $P<0.05$ was considered statistically significant.

RESULTS

From 2014 to 2021, there was a general downward trend in COPD-related mortality (Table 1 and Figure 1). The absolute number of deaths decreased from 180,330 to 149,612, and the ASMR associated with COPD decreased from 91.85 to 45.90 per 100,000 population, with an AAPC of −9.4% (95% *CI*: −10.3 to −8.4%). Males had higher COPD-associated mortality and a milder decrease than females, corresponding to AAPCs of −8.0% (95% *CI*: −9.2 to −6.8%) and −11.2% (95% *CI*: −11.9 to −10.4%), respectively. The Eastern region, with the lowest COPD burden, showed a sharp decline during our study period (AAPC: −10.7%, 95% *CI*: −11.5 to −9.9%), followed by the Central (AAPC: −9.9%, 95% *CI*: −10.9 to −8.9%) and Western (AAPC: −7.7%, 95% *CI*: −10.6 to −4.7%) regions. COPD-associated mortality was higher in rural areas (ASMR: 54.83 per 100,000) than in urban areas (ASMR: 33.75 per 100,000). However, compared to rural areas (AAPC: −8.3%, 95% *CI*: −9.1 to −7.4%), urban areas presented a more substantial drop (AAPC: −10.9%, 95% *CI*: −12.3 to −9.5%).

COPD was the most common underlying cause of death across years, accounting for 92.87% of all deaths (Figure 2A). Aside from COPD, lung cancer, cardiovascular disease, and other chronic respiratory diseases were the major underlying causes of death.

TABLE 1. Number of deaths, crude and age-standardized mortality rates associated with COPD, and temporal trends from 2014 to 2021.

Category	2014			2021			AAPC of age-standardized mortality rate from 2014 to 2021 (95% *CI*)
	Number	Crude mortality rate (1/100,000)	Age-standardized mortality rate (1/100,000)	Number	Crude mortality rate (1/100,000)	Age-standardized mortality rate (1/100,000)	
Total	180,330	69.68	91.85	149,612	47.09	45.90	−9.4% (−10.3, −8.4%)*
Sex							
Females	75,964	60.16	71.27	56,518	36.34	31.09	−11.2% (−11.9, −10.4%)*
Males	104,366	78.76	115.41	93,094	57.41	63.62	−8% (−9.2, −6.8%)*
Residence							
Urban	55,372	53.77	75.27	46,576	32.84	33.75	−10.9% (−12.3, −9.5%)*
Rural	124,958	80.20	101.95	103,036	58.58	54.83	−8.3% (−9.1, −7.4%)*
Region							
Eastern	63,912	56.25	68.87	48,430	32.84	31.21	−10.7% (−11.5, −9.9%)*
Central	50,877	65.13	89.36	40,680	45.22	42.86	−9.9% (−10.9, −8.9%)*
Western	65,541	97.75	139.84	60,502	75.37	78.96	−7.7% (−10.6, −4.7%)*

Abbreviation: COPD=Chronic obstructive pulmonary disease; AAPC=average annual percentage change; *CI*=confidence interval.

* $P<0.001$.

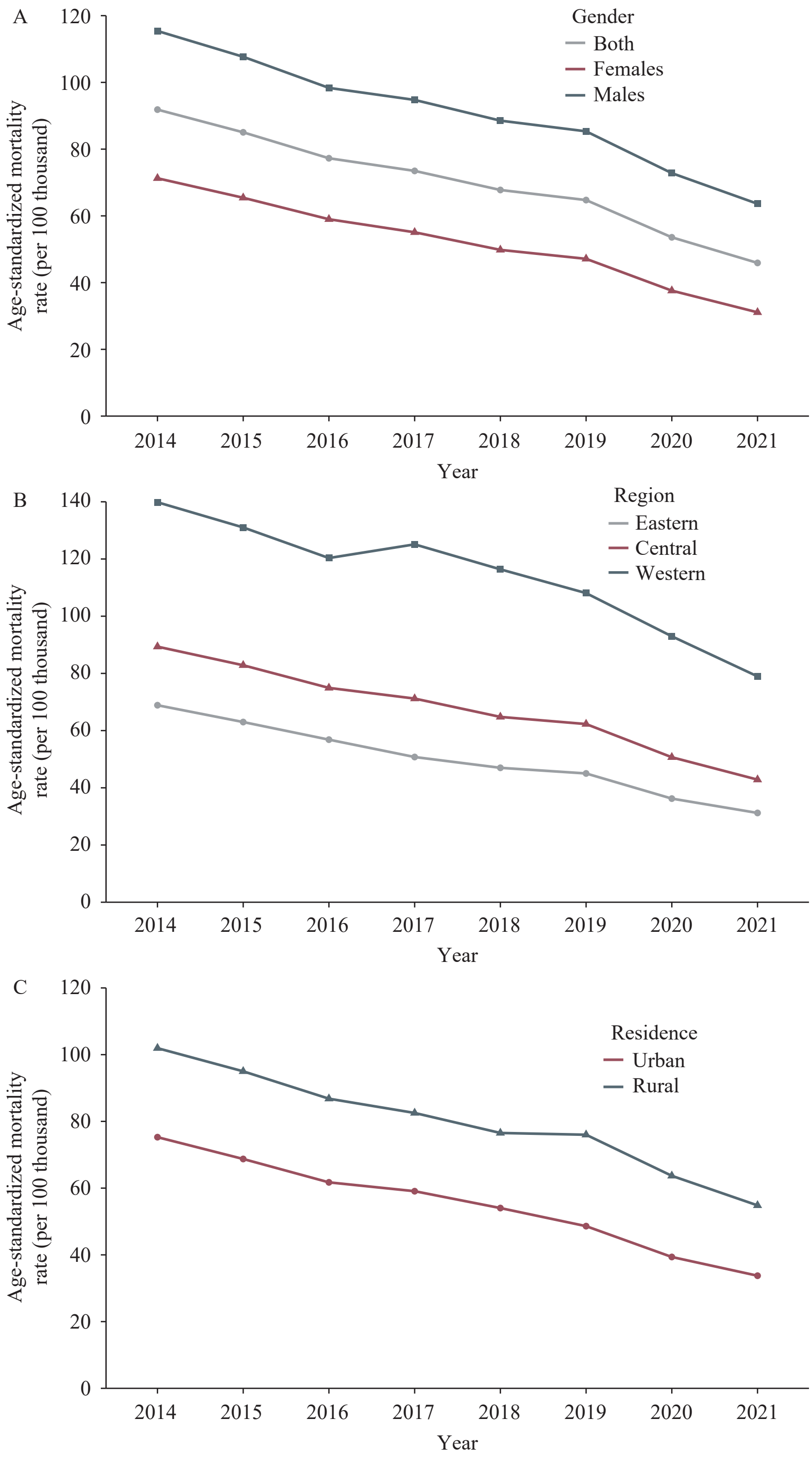


FIGURE 1. Temporal trend in age-standardized mortality rate related to COPD by (A) sex, (B) region, and (C) residence in China from 2014 to 2021.

Abbreviation: COPD=chronic obstructive pulmonary disease.

Malignant neoplasm of the trachea, bronchus, and lung ranked second with a proportion of 2.81%, followed by pulmonary heart disease and diseases of pulmonary circulation (1.00%) and ischemic heart disease (0.69%). Cerebrovascular diseases and asthma ranked seventh and eighth, corresponding to 0.41% and 0.33% of COPD-associated deaths, respectively.

Among all deaths with COPD as the underlying cause of death, the leading contributory cause of death was pulmonary heart disease and diseases of pulmonary

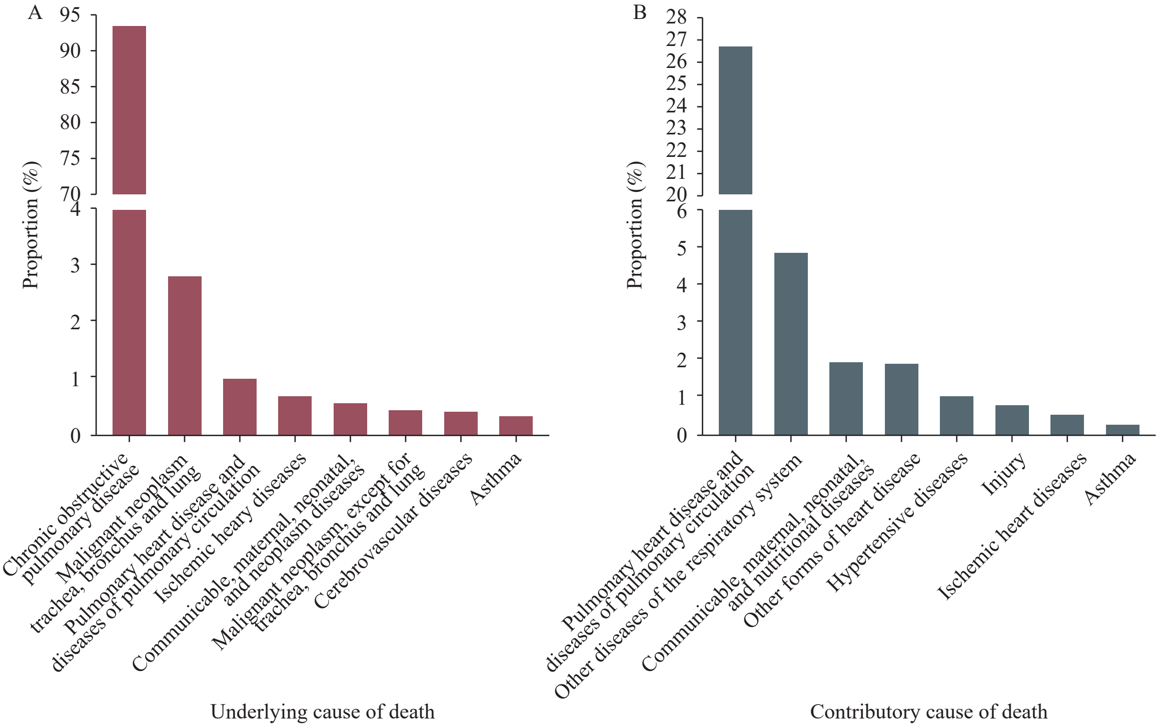


FIGURE 2. Major underlying and contributing causes of death among decedents with COPD in China during 2014–2021. (A) The major underlying causes of death in all deaths related to COPD. (B) The common contributing causes of death in decedents with COPD as the underlying cause of death.
Abbreviation: COPD=Chronic obstructive pulmonary disease.

circulation, with 0.9 million deaths (26.79% of all COPD deaths) (Figure 2B). Other diseases of the respiratory system ranked second, with a proportion of 4.87%. Other forms of heart disease (1.9%), hypertensive diseases (1.03%), and ischemic heart disease (0.54%) ranked fourth, fifth, and seventh, respectively. Asthma, with a proportion of 0.28%, was the eighth most common contributory cause of death in decedents whose underlying cause was COPD.

DISCUSSION

Aside from COPD, cardiovascular diseases and respiratory conditions were the major underlying and leading contributory causes of COPD-associated mortality. From 2014 to 2021, significant downward trends in COPD-associated mortality were observed across genders, regions, and residential areas. Regions and residential areas with advanced economies generally had lower ASMRs and steeper declines in ASMR.

Consistent with other major studies, COPD was found to coexist with a broad set of diseases (comorbidities), with CVDs and respiratory events being the two leading ones. Comorbidities were common at any severity of COPD, and about 97.7% of COPD patients experienced at least one comorbid disease, while 53.5% had four or more (*11*). Some of these comorbidities originated independently from COPD, while others may be causally related to some extent by either sharing common risk factors or mutually exacerbating each other (*12*). For example, COPD and lung cancer were confirmed to share common origins, with tobacco smoking, second-hand smoke, household and outdoor air pollution, and occupational exposures as their common risk factors (*2–3,12*). Additionally, according to the Global Strategy for Prevention, Diagnosis, and Management of COPD: 2024 Report, COPD patients with no preexisting CVDs generally had a 25% higher risk of adverse cardiac events (*12*). However, even though systemic inflammation, the major characteristic of COPD, was documented as one of the potential determinants linking COPD to its main comorbidities, the detailed interaction mechanism is still under-researched (*2,13*).

Complex health conditions, unclear mechanisms, and comorbidities pose significant challenges, particularly in less developed areas. Uneven socioeconomic development substantially contributes to disparities in COPD management and outcomes (*1*,*3*). Limited healthcare resources, reduced social support, inadequate health awareness, and greater exposure to risk factors like biomass fuels and coal are strongly associated with underdeveloped economies. Notably, even in developed areas, individuals with low socioeconomic status may lack access to healthcare services (*14*). The WHO reports that approximately 90% of COPD deaths before the age of 70 occur in low- and middle-income countries (*4*). Yin et al. identified similar disparities, observing higher COPD ASMRs in provinces with low socioeconomic indices, typically located in western China (*1*). Moreover, rural areas in China (*15*), as well as the United States (*3*), experience higher COPD-attributable ASMRs compared to urban areas.

As a heterogeneous condition, COPD requires personalized pharmacological treatment with thorough consideration of comorbidities, symptom severity, exacerbation risk, and side effects (*12*). The emergence of advanced imaging tools, such as computed tomography (CT) and magnetic resonance imaging (MRI), has made in vivo studies of structure-function associations possible and formed the basis for individualized COPD management (*3*). Additionally, with the promotion of clean energy since the 1990s, solid fuel has been gradually replaced by electricity and natural gas in China, attenuating exposure to household air pollution (*1*). Smoking cessation, vaccination, and protection against occupational exposures were highly encouraged, some even required by specific rules or regulations. These measures likely mitigated COPD outcomes and contributed to a general decrease in ASMR over time. However, regions did not benefit evenly, particularly less developed areas. A national cross-sectional survey of rural areas in seven PLADs in China showed that the diagnosis rate of COPD was only 30% (*15*). Moreover, only 7.9% of COPD patients at stage II or above received pharmacological treatment, and 0.3% used regular inhalers and oxygen therapy (*15*). According to the survey, the penetration rate of clean energy remained low, and the smoking cessation rate among COPD patients was 25.5%, indicating low disease awareness and poor self-management (*15*). Therefore, despite a downward trend, ASMR has experienced a relatively mild decline in underdeveloped regions.

To prevent and manage COPD, policymakers should implement stricter actions, particularly in western regions and rural areas. Given that COPD frequently presents with comorbidities and often acts as a severe comorbidity for other disorders, clinicians and patients should pay special attention to potential or existing comorbidities. Individuals diagnosed with CVDs and other respiratory events, such as lung cancer, should be cautious about the development of COPD. Reducing COPD-associated mortality requires controlling common risk factors for COPD and other major adverse health events. For example, avoiding direct or indirect exposure to smoking is a top priority. Therefore, legislative smoking bans and counseling are strongly encouraged nationwide. Additionally, due to the disparities in COPD management and outcomes, more detailed health guidance is needed, especially in underdeveloped regions. Personalized and multidimensional treatment should also be more accessible in the future to mitigate the burden of COPD.

This study estimated recent COPD-associated mortality using data from the NMSS, the most comprehensive source of mortality information in China. This approach provides the most accurate description of the burden and temporal trends in COPD-associated mortality from 2014 to 2021. Additionally, this study included COPD cases based on the chain of events on death certificates rather than solely considering COPD as the underlying cause, capturing comorbidities among decedents with COPD.

However, this study has some inherent limitations. First, death certificates only list diseases, injuries, and complications directly causing death and thus do not provide a complete picture of decedents' pre-existing conditions. Our analysis may not capture individuals with COPD that did not directly result in death. Additionally, underreporting in western regions and low diagnosis rates in rural areas may underestimate COPD-associated mortality. Finally, because data were extracted from death certificates, which do not document lifetime risk factor exposure, our research did not include a risk factor analysis, which is highly warranted in future research.

In conclusion, COPD is a complex, multicomponent condition frequently accompanied by other diseases. Its comorbidities are crucial determinants of outcomes, and COPD itself is an important comorbidity of other disorders. In China, even though COPD-associated mortality presented a substantial decreasing trend from 2014 to 2021, the COPD burden remained high in underdeveloped regions. This indicates that COPD is still a severe public health issue in China, and healthcare resources may not be evenly distributed. Therefore, public health officials should prioritize a region-specific strategy for the management and prevention of COPD to alleviate the burden of disease.

Conflicts of interest: No conflicts of interest.

Acknowledgements: The provincial and local Centers for Disease Control and Prevention across China.

doi: 10.46234/ccdcw2024.226

Corresponding author: Peng Yin, yinpeng@ncncd.chinacdc.cn.

---

[1] National Center for Chronic and Non-communicable Disease Control and Prevention, Chinese Center for Disease Control and Prevention, Beijing, China.

Submitted: July 22, 2024; Accepted: September 04, 2024

REFERENCES

1. Yin P, Wu JY, Wang LJ, Luo CL, Ouyang LH, Tang XT, et al. The burden of COPD in China and its provinces: findings from the global burden of disease study 2019. Front Public Health 2022;10:859499. https://doi.org/10.3389/fpubh.2022.859499.
2. Negewo NA, Gibson PG, McDonald VM. COPD and its comorbidities: impact, measurement and mechanisms. Respirology 2015;20(8):1160 – 71. https://doi.org/10.1111/resp.12642.
3. Christenson SA, Smith BM, Bafadhel M, Putcha N. Chronic obstructive pulmonary disease. Lancet 2022;399(10342):2227 – 42. https://doi.org/10.1016/S0140-6736(22)00470-6.
4. WHO. Chronic obstructive pulmonary disease (COPD). 2023. https://www.who.int/news-room/fact-sheets/detail/chronic-obstructive-pulmonary-disease-(copd). [2023-3-16]
5. WHO. WHO report on the global tobacco epidemic 2021: addressing new and emerging products. Geneva: WHO; 2022. https://iris.who.int/bitstream/handle/10665/343287/9789240032095-eng.pdf?sequence=1.
6. Han YT, He Y, Lyu J, Yu CQ, Bian MZ, Lee L. Aging in China: perspectives on public health. Global Health J 2020;4(1):11 – 7. https://doi.org/10.1016/j.glohj.2020.01.002.
7. Fang LW, Gao P, Bao HL, Tang X, Wang BH, Feng YJ, et al. Chronic obstructive pulmonary disease in China: a nationwide prevalence study. Lancet Respir Med 2018;6(6):421 – 30. https://doi.org/10.1016/S2213-2600(18)30103-6.
8. WHO. Advancing COPD care in China through a comprehensive approach. Geneva: WHO; 2023. https://www.who.int/news-room/feature-stories/detail/advancing-copd-care-in-china-through-a-comprehensive-approach.
9. Liu SW, Wu XL, Lopez AD, Wang LJ, Cai Y, Page A, et al. An integrated national mortality surveillance system for death registration and mortality surveillance, China. Bull World Health Organ 2016;94(1):46 – 57. https://doi.org/10.2471/BLT.15.153148.
10. Guo K, Yin P, Wang LJ, Ji YB, Li QF, Bishai D, et al. Propensity score weighting for addressing under-reporting in mortality surveillance: a proof-of-concept study using the nationally representative mortality data in China. Popul Health Metr 2015;13:16. https://doi.org/10.1186/s12963-015-0051-3.
11. Vanfleteren LEGW, Spruit MA, Groenen M, Gaffron S, van Empel VPM, Bruijnzeel PLB, et al. Clusters of comorbidities based on validated objective measurements and systemic inflammation in patients with chronic obstructive pulmonary disease. Am J Respir Crit Care Med 2013;187(7):728 – 35. https://doi.org/10.1164/rccm.201209-1665OC.
12. Global Initiative for Chronic Obstructive Lung Disease (GOLD). Global strategy for prevention, diagnosis and management of copd: 2024 report. 2024. Available: https://goldcopd.org/2024-gold-report/. [2023-12-4].
13. Wang ZH, Sun YC. Unraveling the causality between chronic obstructive pulmonary disease and its common comorbidities using bidirectional Mendelian randomization. Eur J Med Res 2024;29(1):143. https://doi.org/10.1186/s40001-024-01686-x.
14. Duvall K, Frank GW. Identifying chronic obstructive pulmonary disease in primary care of urban underserved patients: tools, applications, and challenges. J Natl Med Assoc 2010;102(7):570 – 8. https://doi.org/10.1016/S0027-9684(15)30623-4.
15. Zhou YM, Wang C, Yao WZ, Chen P, Kang J, Huang SG, et al. Current status of prevention and management of chronic obstructive pulmonary disease in rural area in China. Chin J Intern Med 2009;48(5):358 – 61. https://doi.org/10.3760/cma.j.issn.0578-1426.2009.05.003.

Vital Surveillances

Rate and Change in Household Solid Fuels Usage Among Residents Aged 40 and Older — China, from 2014–2015 to 2019–2020

Wenjing Wang[1]; Shu Cong[1]; Jing Fan[1]; Ning Wang[1]; Qian Wang[2]; Liwen Fang[1,#]

ABSTRACT

Introduction: Solid fuel combustion is a significant source of household air pollution and an important risk factor for chronic obstructive pulmonary disease (COPD). This study presents the rates and change in the use of solid fuels for cooking and heating in China.

Methods: Based on data from the Chinese Chronic Obstructive Pulmonary Disease Surveillance, the research estimated the rates and change of solid fuels usage for cooking and heating from 2014–2015 to 2019–2020 and the rate of primary cooking solid fuels usage in 2019–2020, and analyzed the association between solid fuels usage and COPD.

Results: The rates of solid fuels usage for cooking and heating significantly decreased, dropping from 45.3% to 28.0% and from 33.5% to 23.2%, respectively. Usage rates were higher among rural residents, with 47.2% using it for cooking and 37.7% for heating in 2019-2020. The usage of solid fuels for cooking is associated with increased risk of COPD. Among rural residents, combined usage of biomass and coal for cooking (*OR*=1.29, 95% *CI*: 1.12, 1.48) and using coal as primary fuel for cooking (*OR*=1.18, 95% *CI*: 1.00, 1.38) are associated with higher risk of COPD. The usage of biomass for cooking is associated with an increased risk of COPD in urban residents (*OR*=1.17, 95% *CI*: 1.03, 1.32).

Conclusions: The study demonstrates a significant decline in the use of household solid fuels. Nevertheless, high utilization rates persist among individuals in rural settings and those from lower socioeconomic backgrounds. It is of great public health importance to propose targeted fuel substitution measures for various solid fuels in different regions to reduce the risk of COPD.

Solid fuel combustion is a significant source of household air pollution (HAP) and an important risk factor for chronic obstructive pulmonary disease (COPD) and various health risks(*1*–*3*). Exposure to biomass has been shown to significantly increase the risk of developing COPD (*4*). Globally, HAP from solid fuels is responsible for an estimated loss of 86 million healthy life years and causes around 3.2 million deaths annually (*2*).

The United Nations has established the Sustainable Development Goals (SDGs), specifically SDG7, which aims to ensure universal access to affordable, reliable, sustainable, and modern energy (*5*). In response to economic reforms and rural development programs, there has been a rapid transformation in household energy use in China (*6*). Despite this progress, existing literature only includes data on the use of cooking solid fuels until 2015, and there is a notable deficiency in recent data and information concerning the utilization of solid fuels for heating (*6*–*8*). Additionally, the common practice of “fuel stacking,” where individuals use traditional fuels in conjunction with clean fuels, is prevalent in China (*6*,*9*). If evaluations only consider the primary fuel source, the exposure to HAP may be significantly underestimated. Nevertheless, only a limited number of surveys have gathered data on secondary fuel usage.

This study utilized data from the Chinese COPD surveillance to assess the prevalence and changes in the usage of solid fuels for cooking and heating in China between 2014–2015 and 2019–2020. Additionally, the analysis explored the prevalence of primary and partial use of solid fuels for cooking. These insights enhance the accuracy of estimations regarding household solid fuel exposure and inform the development of policies aimed at preventing related diseases.

METHODS

The data analyzed were sourced from the Chinese COPD surveillance, which involved participants aged 40 and above from 125 surveillance points in 31 provinces. This research employed a complex, multistage, and probability-based sampling methodology. The detailed information about the study design and participants recruitment has been introduced previously (*10*). Following the exclusion of participants lacking fuel-related information, the final analyses comprised data from 75,033 participants from the 2014–2015 survey and 74,556 from the 2019–2020 survey.

Data on general characteristics and utilization of solid fuels were collected through a structured questionnaire managed by trained enumerators. Biomass fuels captured in this analysis included charcoal, wood, crop waste, and animal dung, while coal types consisted of kerosene, paraffin, anthracite, and bitumite. Primary cooking solid fuels use is defined as utilizing solid fuels as the main source of energy for cooking. Cooking solid fuels use encompasses both primary and partial use of biomass or coal for cooking. Similarly, heating solid fuels use is described as utilizing biomass or coal for heating purposes. The Gross Domestic Product (GDP) per capita for the year 2014 and 2019 of each county was sourced from the Statistical Yearbook and categorized into four levels — low, lower-middle, upper-middle, and high — based on median values and quartiles. Geographically, the locations were divided into seven regions: North China, East China, Central China, South China, Southwest China, Northwest China, and Northeast China[*].

The weighted rates and 95% confidence intervals (*CI*s) of solid fuels use across the overall population and various subgroups were calculated. These weights accounted for the survey's sampling scheme and incorporated post-stratification adjustments to align with the demographic structure of China's 2020 Census. Taylor series linearization, accommodating the complex sampling design, was employed to estimate the 95% *CI*s. Differences among subgroups and changes in solid fuels usage from 2014–2015 to 2019–2020 were evaluated using Rao-Scott chi-squared tests. All statistical analyses were performed using SAS software (version 9.4; SAS Institute Inc., Cary, USA), and all tests were two-tailed with a significance threshold set at 0.05.

RESULT

In the 2019–2020 survey, 59.6% of the participants lived in urban areas, 38.0% were aged 60 or older, and 46.0% had attained education up to primary school or less. There were no significant differences in the weighted proportions of these characteristics when compared to the 2014–2015 data (*P*>0.05). The average GDP per capita increased from 48,872.2 Chinese Yuan (CNY) in 2014–2015 to 64,323.1 CNY in 2019–2020 (*P*<0.001) (Table 1).

Solid Fuels Use for Cooking and Heating and Its Changes

The usage rates of solid fuels for cooking were 45.3% (95% *CI*: 38.5%, 52.2%) and 28.0% (95% *CI*: 22.6%, 33.5%) for the periods 2014–2015 and 2019–2020, respectively. Similarly, the rates for heating were 33.5% (95% *CI*: 26.2%, 40.7%) and 23.2% (95% *CI*: 17.1%, 29.2%) for the same periods (Table 2). In the years 2019–2020, 38.0% of residents used solid fuels for either cooking or heating, with 15.8% primarily using solid fuels for cooking (Table 2, Supplementary Table S1, available at https://weekly.chinacdc.cn/). Residents from rural areas demonstrated higher usage rates, with 47.2% using solid fuels for cooking, and 37.7% for heating, respectively, in 2019–2020. The elderly, less educated individuals, and those from regions with a lower GDP had elevated usage rates of solid fuels in 2019–2020 (*P*<0.05) (Table 2, Supplementary Table S2, available at https://weekly.chinacdc.cn/).

The use of solid fuels for cooking decreased by 17.3%. This significant reduction was observed across all regions, with Central China experiencing the most substantial decrease of 33.5%. Similarly, the use of solid fuels for heating fell by 10.3%, although only North China demonstrated a significant decline, dropping from 53.6% to 14.6% (Table 2).

Biomass Use for Cooking and Heating and Its Changes

The prevalence of cooking biomass utilization was recorded at 35.5% (95% *CI*: 29.2%, 41.8%) and 24.0% (95% *CI*: 18.8%, 29.1%), while heating biomass utilization stood at 8.4% (95% *CI*: 5.1%, 11.7%) and 10.1% (95% *CI*: 6.5%, 13.8%) in the periods 2014–2015 and 2019–2020, respectively. Both surveys indicated higher biomass use for cooking and heating in rural areas, among elderly populations, those

---

[*] North China: Beijing, Tianjin, Hebei, Shanxi, and Inner Mongolia. East China: Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, and Shandong. Central China: Henan, Hubei, and Hunan. South China: Guangdong, Guangxi, and Hainan. Southwest China: Chongqing, Sichuan, Guizhou, Yunnan, and Xizang. Northwest China: Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang. Northeast China: Liaoning, Heilongjiang, and Jilin.

TABLE 1. Characteristics of participants in the 2014–2015 and 2019–2020 surveys.

Characteristic	2014–2015		2019–2020		*P*
	N[*]	%[†]	*N*[*]	%[†]	
Area type					
Urban	35,666	59.6	34,236	59.6	0.998
Rural	39,367	40.4	40,320	40.4	
Age, years					
40–49	23,491	29.9	17,635	29.9	1.000
50–59	24,497	32.1	26,325	32.1	
60–69	19,858	21.2	22,766	21.2	
≥70	7,187	16.8	7,830	16.8	
Ethnicity[§]					
Han	66,768	95.9	66,890	95.2	0.289
Others	8,263	4.1	7,666	4.8	
Educational level[§]					
Primary school or below	38,687	48.3	37,674	46.0	0.248
Junior high and above	36,344	51.7	36,882	54.0	
Occupation[§]					
Agriculture	34,937	39.6	31,462	32.1	0.004
Others	40,094	60.4	43,094	67.9	
GDP per capita, CNY, $\overline{X}$ (S)[¶]	48,872.2	26,815.6	64,323.1	36,773.7	<0.001
Area					
East	26,453	42.7	25,874	42.7	1.000
Central	22,186	30.6	22,763	30.6	
West	26,394	26.7	25,919	26.7	
Region					
North China	10,199	15.9	10,182	15.6	0.679
East China	19,173	29.7	19,243	30.7	
Central China	8,978	15.9	9,603	15.3	
South China	7,640	8.7	8,067	6.0	
Southwest China	12,226	15.2	12,117	18.5	
Northwest China	9,027	6.6	8,365	5.6	
Northeast China	7,790	8.0	6,979	8.3	

Abbreviation: GDP=Gross domestic product, CNY=Chinese Yuan, $\overline{X}$=mean, S=standard deviation.

[*] No. of participants was the unweighted number of subcategories denominator.

[†] The percentages were weighted.

[§] Data missing in survey 2014 for Ethnicity (n=2), Education level (n=2), Occupation (n=2).

[¶] P values for GDP per capita were calculated using t test.

with lower educational attainment, and in regions with lower GDP per capita (P<0.05).

The use of biomass for cooking decreased by 11.5%, with significant reductions observed in all regions except East China. Specifically, biomass use for heating increased by 9.2% in South China and 7.0% in Central China, while it decreased by 6.2% in Northeast China and 2.8% in North China (Table 3).

Coal Use for Cooking and Heating and Its Changes

The utilization rates of cooking coal decreased from 15.4% (95% *CI*: 10.8%, 19.9%) in 2014–2015 to 6.8% (95% *CI*: 4.6%, 9.0%) in 2019–2020. Likewise, the rates for heating coal use declined from 25.0% (95% *CI*: 18.3%, 31.8%) in 2014–2015 to 13.0%

TABLE 2. Rates and changes in solid fuels use for cooking and heating from 2014–2015 to 2019–2020, and the prevalence of primary solid fuels use for cooking in 2019–2020 among residents aged 40 and older in China, categorized by residence, age, educational level, GDP per capita, and region.

Characteristic	Cooking			Heating			Primary cooking[*]
	2014–2015	2019–2020	Absolute change (%)[†]	2014–2015	2019–2020	Absolute change (%)[†]	2019–2020
	Rate (95% *CI*)	Rate (95% *CI*)		Rate (95% *CI*)	Rate (95% *CI*)		Rate (95% *CI*)
Overall	45.3 (38.5, 52.2)	28.0 (22.6, 33.5)	−17.3[§] (−22.1, −12.5)	33.5 (26.2, 40.7)	23.2 (17.1, 29.2)	−10.3[§] (−17.1, −3.5)	15.8 (12.2, 19.4)
Residence							
Urban	30.0 (22.7, 37.3)	15.0 (10.6, 19.5)	−15.0[§] (−21.0, −8.9)	23.3 (16.7, 29.9)	13.3 (8.2, 18.4)	−10.0[§] (−17.0, −3.0)	7.3 (4.8, 9.7)
Rural	67.9 (61.6, 74.2)	47.2 (41.8, 52.6)	−20.7[§] (−27.0, −14.5)	48.4 (37.8, 59.02)	37.7 (29.3, 46.1)	−10.7[§] (−20.1, −1.3)	28.5 (23.4, 33.5)
χ^2	152.721	–[¶]		29.463	59.457		495.980
P	<0.001	<0.001		<0.001	<0.001		<0.001
Age, years							
40–49	39.1 (32.5, 45.6)	19.1 (14.8, 23.4)	−20.0[§] (−25.2, −14.7)	30.9 (23.9, 37.9)	19.6 (14.1, 25.2)	−11.3[§] (−18.1, −4.4)	9.4 (6.7, 12.2)
50–59	43.6 (36.2, 51.0)	26.3 (21.3, 31.3)	−17.4[§] (−22.5, −12.2)	34.9 (27.4, 42.4)	23.0 (17.0, 28.9)	−11.9[§] (−19.4, −4.4)	12.9 (9.8, 15.9)
60–69	51.1 (42.7, 59.5)	34.2 (26.8, 41.6)	−16.9[§] (−22.7, −11.1)	34.2 (26.1, 42.4)	24.3 (17.5, 31.2)	−9.9[§] (−17.7, −2.2)	19.9 (15.1, 24.7)
≥70	52.4 (44.7, 60.1)	39.5 (31.6, 47.4)	−13.0[§] (−20.8, −5.1)	34.3 (25.7, 42.9)	28.3 (19.9, 36.7)	−6.0 (−14.1, 2.1)	27.7 (21.3, 34.1)
χ^2	37.203	132.462		4.943	17.812		174.460
P	<0.001	<0.001		0.176	<0.001		<0.001
Educational level							
Primary school or below	60.1 (54.1, 66.0)	42.0 (36.9, 47.0)	−18.1[§] (−23.3, −12.9)	38.3 (29.7, 46.9)	31.3 (24.1, 38.5)	−7.0[§] (−12.9, −1.1)	25.8 (21.6, 29.9)
Junior high or above	31.5 (24.5, 38.6)	16.1 (11.4, 20.9)	−15.4[§] (−20.0, −10.8)	28.9 (21.4, 36.4)	16.2 (10.5, 21.8)	−12.7[§] (−21.1, −4.3)	7.3 (4.9, 9.7)
χ^2	–[¶]	–[¶]		7.124	36.407		–[¶]
P	<0.001	<0.001		0.008	<0.001		0.031
GDP per capita							
Low	60.1 (51.1, 69.0)	40.1 (29.0, 51.1)	−20.0[§] (−33.1, −6.9)	35.2 (20.7, 49.8)	34.1 (20.7, 47.4)	−1.2 (−16.1, 13.8)	25.5 (17.2, 33.8)
Lower-middle	62.1 (51.8, 72.3)	38.4 (28.8, 48.0)	−23.7[§] (−34.2, −13.2)	33.6 (18.9, 48.3)	33.4 (19.2, 47.7)	−0.2 (−14.1, 13.8)	21.1 (12.9, 29.2)
Upper-middle	45.4 (32.1, 58.8)	33.9 (28.3, 39.5)	−11.5 (−25.7, 2.7)	39.4 (25.8, 53.0)	30.2 (19.8, 40.6)	−9.2 (−24.7, 6.3)	20.3 (15.7, 24.9)
High	25.1 (15.0, 35.3)	12.2 (5.6, 18.8)	−12.9[§] (−20.1, −5.8)	28.3 (13.7, 42.9)	7.1 (0.6, 13.7)	−21.2[§] (−36.0, −6.4)	5.0 (1.9, 8.1)
χ^2	34.856	42.219		1.327	20.121		39.621
P	<0.001	<0.001		0.723	<0.001		<0.001
Region							
North China	25.1 (10.9, 39.3)	12.8 (0.0, 25.7)	−12.2[§] (−15.7, −8.8)	53.6 (39.9, 67.2)	14.6 (0.5, 28.6)	−39.0[§] (−57.7, −20.3)	8.1 (0.0, 18.1)
East China	43.6 (28.9, 58.3)	29.5 (19.5, 39.6)	−14.1[§] (−25.9, −2.2)	25.5 (10.8, 40.2)	20.8 (8.6, 33.1)	−4.6 (−12.7, 3.4)	14.1 (7.9, 20.2)
Central China	56.3 (40.8, 71.8)	22.8 (13.4, 32.2)	−33.5[§] (−49.5, −17.5)	34.0 (19.0, 49.1)	26.9 (13.6, 40.1)	−7.2 (−19.3, 4.9)	12.5 (7.0, 17.9)
South China	50.9 (31.8, 70.1)	32.6 (16.8, 48.4)	−18.3[§] (−28.6, −8.1)	14.0 (3.0, 25.1)	13.3 (1.1, 25.5)	−0.7 (−8.4, 6.9)	15.7 (7.0, 24.3)
Southwest China	51.2 (39.8, 62.6)	37.5 (28.6, 46.4)	−13.6[§] (−23.4, −3.9)	22.7 (7.0, 38.3)	16.9 (6.2, 27.7)	−5.7 (−16.4, 5.0)	22.0 (16.0, 28.0)

Continued

Characteristic	Cooking			Heating			Primary cooking*
	2014–2015	2019–2020	Absolute change (%)†	2014–2015	2019–2020	Absolute change (%)†	2019–2020
	Rate (95% *CI*)	Rate (95% *CI*)		Rate (95% *CI*)	Rate (95% *CI*)		Rate (95% *CI*)
Northwest China	47.9 (26.4, 69.4)	30.2 (15.5, 45.0)	−17.7§ (−35.0, −0.4)	47.7 (26.1, 69.3)	50.0 (31.1, 68.8)	2.2 (−19.7, 24.1)	20.4 (7.6, 33.2)
Northeast China	50.8 (31.9, 69.7)	34.6 (16.1, 53.1)	−16.2§ (−26.6, −5.8)	51.7 (34.0, 69.4)	44.0 (22.8, 65.1)	−7.7 (−20.9, 5.5)	26.4 (11.0, 41.8)
χ^2	10.823	11.786		20.267	15.052		10.741
P	0.094	0.067		0.003	0.020		0.097

Note: The difference in the rate of solid fuels use between 2014–2015 and 2019–2020 was tested using Rao−Scott χ^2.

[*] Primary cooking solid fuels means that using solid fuels as primary energy for cooking.

[†] Absolute change equals prevalence in 2019 minus prevalence in 2014.

[§] means $P<0.05$.

[¶] The value of Rao−Scott χ^2 could not be calculated.

(95% *CI*: 8.4%, 17.6%) in 2019–2020. In 2019–2020, higher utilization rates of both cooking and heating coal were observed among rural residents, individuals with lower educational attainment, and regions with lower GDP per capita.

The utilization of cooking coal decreased by 8.6%, with significant reductions observed across all regions except South China and Northwest China. Usage of heating coal also fell by 12.0%, with significant decreases in all regions except Northwest China. North China registered the largest drop, from 50.0% to 13.8% (Table 4).

The Effect of Solid Fuel Usage on COPD

As shown in Table 5, the usage of biomass for cooking is associated with an increased risk of COPD in urban residents (*OR*=1.17, 95% *CI*: 1.03, 1.32). Among rural residents, combined use of biomass and coal fuels for cooking (*OR*=1.29, 95% *CI*: 1.12, 1.48), using coal as primary fuel for cooking (*OR*=1.18 95% *CI*: 1.00, 1.38), and using solid fuels for cooking or heating are associated with higher risk of COPD (*P*<0.05) (Table 5).

DISCUSSION

The usage rate of solid fuels is an important indicator reflecting the prevalence and change of solid fuels exposure, one of the major risk factors for COPD. Understanding the usage rate of solid fuels and its changes in China can provide baseline data for assessing the attributable disease burden of COPD and inform the development of policies to prevent COPD. Solid fuels use significantly contributes to HAP, disease burden, and health degradation in low- and middle-income countries (*1*). This study presents updated, comprehensive, and nationally representative data on the prevalence of solid fuels use for cooking, encompassing both primary and partial usage. According to the World Health Organization (WHO), in 2019, 20.6% of China's population primarily relied on polluting fuels and technologies for cooking (*1*). Our findings show a primary solid fuels use rate of 15.8% among individuals aged 40 and above (*1*), but a total usage rate of 28.0%, indicating that relying solely on primary fuel data may lead to underestimations by nearly 50%. Additionally, the simultaneous use of both traditional and clean stoves and technologies curbs the potential benefits for health and the environment (*11*). Therefore, it is imperative to implement measures that decrease reliance on traditional solid fuel systems and foster new social preferences to facilitate a complete transition to clean energy (*9*).

Data on the use of solid fuels for heating are scarce both globally and within China. The WHO currently only provides data on solid fuels used for cooking, with plans to expand coverage to include heating and lighting fuels starting in 2022 (*1*). Our study indicates that about 60% of household solid fuels consumption can be attributed to heating. Consequently, it is essential to assess the use of solid fuels for heating in studies aimed at estimating disease risks and the burden of HAP exposure. Furthermore, effective interventions, such as clean heating renovations (*12*), must be implemented to reduce the reliance on solid fuels for heating.

The usage rates of solid fuels for cooking and heating decreased by 17.3% and 10.3%, respectively, from 2014–2015 to 2019–2020, exceeding both the global benchmarks and previous trends observed in

TABLE 3. Rates and changes in biomass usage for cooking and heating among residents aged 40 and above in China, from 2014–2015 to 2019–2020, categorized by residence, age, educational level, GDP per capita, and region.

Characteristic	Cooking			Heating		
	2014–2015	2019–2020	Absolute change (%)[*]	2014–2015	2019–2020	Absolute change (%)[*]
	Rate (95% *CI*)	Rate (95% *CI*)		Rate (95% *CI*)	Rate (95% *CI*)	
Overall	35.5 (29.2, 41.8)	24.0 (18.8, 29.1)	−11.5[†] (−15.6, −7.5)	8.4 (5.1, 11.7)	10.1 (6.5, 13.8)	1.7 (−0.7, 4.2)
Residence						
Urban	21.0 (15.2, 26.7)	11.6 (7.8, 15.3)	−9.4[†] (−14.4, −4.4)	3.8 (1.5, 6.2)	5.8 (2.4, 9.2)	2.0[†] (−0.1, 4.1)
Rural	56.9 (49.3, 64.6)	42.3 (36.5, 48.1)	−14.6[†] (−21.7, −7.5)	15.2 (9.6, 20.7)	16.5 (11.4, 21.6)	1.3 (−3.6, 6.3)
χ^2	122.638	–[¶]		35.743	20.685	
P	<0.001	<0.001		<0.001	<0.001	
Age, years						
40–49	28.4 (23.2, 33.6)	15.0 (11.2, 18.7)	−13.5[†] (−17.1, −9.8)	6.7 (3.8, 9.5)	7.3 (4.0, 10.5)	0.6 (−1.7, 2.9)
50–59	33.6 (27.0, 40.1)	22.0 (17.4, 26.7)	−11.5[†] (−15.8, −7.3)	8.1 (4.9, 11.3)	9.4 (6.1, 12.7)	1.3 (−0.9, 3.5)
60–69	42.4 (34.0, 50.8)	30.3 (23.2, 37.3)	−12.1[†] (−17.5, −6.8)	8.8 (5.7, 11.9)	11.4 (7.4, 15.4)	2.6[†] (−0.1, 5.3)
≥70	43.1 (35.4, 50.7)	35.7 (27.9, 43.5)	−7.3 (−15.1, 0.4)	11.6 (5.9, 17.3)	15.0 (9.1, 21.0)	3.4 (−2.8, 9.6)
χ^2	58.384	169.536		20.045	35.931	
P	<0.001	<0.001		<0.001	<0.001	
Educational level						
Primary school or below	49.5 (43.3, 55.7)	37.0 (31.7, 42.4)	−12.5[†] (−17.4, −7.5)	12.4 (7.9, 16.9)	16.1 (10.7, 21.4)	3.7[†] (−0.2, 7.5)
Junior high or above	22.4 (16.8, 28.1)	12.9 (8.8, 16.9)	−9.6[†] (−12.9, −6.3)	4.7 (2.4, 7.0)	5.1 (2.9, 7.3)	0.4 (−1.0, 1.9)
χ^2	–[¶]	–[¶]		67.479	178.330	
P	<0.001	<0.001		<0.001	<0.001	
GDP per capita						
Low	49.2 (38.5, 59.9)	35.3 (24.1, 46.5)	−13.9 (−27.9, 0.0)	8.8 (3.6, 14.0)	12.0 (6.0, 18.0)	3.2 (−2.5, 9.0)
Lower-middle	49.6 (40.6, 58.7)	30.8 (20.0, 41.5)	−18.8[†] (−28.2, −9.5)	11.4 (4.9, 17.8)	13.8 (2.3, 25.3)	2.5 (−9.1, 14.0)
Upper-middle	34.7 (23.0, 46.3)	30.0 (24.4, 35.5)	−4.7 (−17.2, 7.9)	14.8 (4.2, 25.5)	17.7 (9.7, 25.7)	2.9 (−9.7, 15.4)
High	18.4 (9.2, 27.6)	10.4 (4.3, 16.6)	−8.0[†] (−13.6, −2.4)	1.7 (0.0, 3.5)	1.8 (0.0, 3.9)	0.1 (−1.1, 1.2)
χ^2	29.242	28.512		14.032	16.269	
P	<0.001	<0.001		0.003	0.001	
Region						
North China	15.5 (2.5, 28.5)	10.5 (0.0, 21.9)	−5.0[†] (−8.5, −1.5)	3.6 (0.0, 9.4)	0.8 (0.0, 1.6)	−2.8[†] (−8.8, 3.2)
East China	33.3 (21.8, 44.7)	25.0 (15.3, 34.6)	−8.3 (−17.1, 0.5)	6.4 (0.0, 14.3)	8.2 (1.0, 15.4)	1.8 (−2.3, 5.9)
Central China	38.1 (23.7, 52.4)	18.1 (9.4, 26.8)	−20.0[†] (−33.1, −6.8)	13.2 (4.3, 22.0)	20.2 (6.2, 34.2)	7.0[†] (−0.9, 15.0)
South China	44.4 (26.7, 62.1)	27.6 (13.2, 42.0)	−16.8[†] (−26.0, −7.5)	4.0 (0.9, 7.1)	13.2 (1.1, 25.3)	9.2[†] (−1.2, 19.7)
Southwest China	43.9 (31.3, 56.5)	34.0 (24.6, 43.3)	−9.9[†] (−19.9, 0.0)	7.4 (2.4, 12.4)	9.5 (2.9, 16.1)	2.1 (−4.2, 8.5)
Northwest China	40.6 (19.5, 61.7)	20.7 (9.4, 31.9)	−19.9[†] (−35.5, −4.3)	6.8 (0.0, 17.5)	6.6 (0.5, 12.7)	−0.2 (−6.2, 5.7)
Northeast China	48.5 (30.0, 67.0)	33.7 (15.2, 52.2)	−14.8[†] (−26.1, −3.5)	24.2 (15.2, 33.1)	18.0 (6.9, 29.1)	−6.2[†] (−13.9, 1.5)
χ^2	12.863	13.123		13.992	17.483	
P	0.045	0.041		0.030	0.008	

Note: The difference in the rate of biomass use between 2014–2015 and 2019–2020 was tested using Rao−Scott χ^2.

[*] Absolute change is calculated as the prevalence in 2019 minus the prevalence in 2014.

[†] means *P*<0.05.

[¶] The value of Rao−Scott χ^2 could not be calculated.

TABLE 4. Rates and changes in coal use for cooking and heating among residents aged 40 and older in China, from 2014–2015 to 2019–2020, categorized by residence, age, educational level, GDP per capita, and region.

Characteristic	Cooking			Heating		
	2014–2015	2019–2020	Absolute change (%)[*]	2014–2015	2019–2020	Absolute change (%)[*]
	Rate (95% *CI*)	Rate (95% *CI*)		Rate (95% *CI*)	Rate (95% *CI*)	
Overall	15.4 (10.8, 19.9)	6.8 (4.6, 9.0)	−8.6[†] (−12.1, −5.1)	25.0 (18.3, 31.8)	13.0 (8.4, 17.6)	−12.0[†] (−18.6, −5.5)
Residence						
Urban	13.0 (8.2, 17.8)	5.2 (3.1, 7.4)	−7.7[†] (−11.9, −3.6)	19.5 (13.5, 25.4)	7.5 (3.9, 11.0)	−12.0[†] (−18.2, −5.9)
Rural	18.9 (13.0, 24.9)	9.1 (6.1, 12.1)	−9.9[†] (−14.6, −5.1)	33.3 (23.4, 43.1)	21.2 (14.1, 28.4)	−12.0[†] (−21.5, −2.5)
χ^2	4.647	8.925		13.654	37.030	
P	0.031	0.003		<0.001	0.003	
Age, years						
40-49	15.3 (10.5, 20.0)	6.0 (3.7, 8.4)	−9.2[†] (−13.3, −5.1)	24.2 (17.8, 30.7)	12.4 (7.9, 16.8)	−11.9[†] (−18.3, −5.4)
50-59	15.6 (11.0, 20.2)	6.8 (4.7, 8.8)	−8.8[†] (−12.6, −5.1)	26.8 (19.5, 34.0)	13.6 (8.8, 18.4)	−13.2[†] (−20.6, −5.8)
60-69	15.2 (10.8, 19.5)	7.1 (4.7, 9.5)	−8.1[†] (−11.7, −4.5)	25.5 (18.1, 32.8)	12.9 (7.9, 17.9)	−12.6[†] (−19.7, −5.4)
≥70	15.5 (9.1, 21.8)	7.8 (4.4, 11.2)	−7.7[†] (−12.9, −2.4)	22.6 (15.3, 30.0)	13.3 (7.6, 18.9)	−9.4[†] (−15.9, −2.9)
χ^2	0.088	3.444		6.004	1.024	
P	0.993	0.328		0.111	0.796	
Educational level						
Primary school or below	17.7 (12.1, 23.4)	8.9 (6.0, 11.9)	−8.8[†] (−13.1, −4.5)	25.9 (18.8, 33.0)	15.3 (10.0, 20.5)	−10.7[†] (−16.4, −4.9)
Junior high or above	13.2 (9.0, 17.3)	5.0 (3.1, 6.8)	−8.2[†] (−11.7, −4.7)	24.2 (16.8, 31.7)	11.1 (6.4, 15.8)	−13.1[†] (−21.3, −5.0)
χ^2	6.139	21.611		0.365	4.673	
P	0.013	<0.001		0.546	0.031	
GDP per capita						
Low	17.2 (7.7, 26.7)	8.4 (2.7, 14.1)	−8.8[†] (−15.6, −2.1)	26.5 (13.8, 39.2)	22.1 (10.4, 33.7)	−4.4 (−18.2, 9.4)
Lower-middle	21.4 (11.3, 31.6)	11.7 (5.9, 17.4)	−9.8[†] (−19.9, 0.3)	22.2 (10.5, 34.0)	19.6 (8.4, 30.7)	−2.6 (−14.9, 9.6)
Upper-middle	15.7 (4.5, 26.9)	7.5 (3.1, 12.0)	−8.1 (−19.9, 3.6)	24.5 (13.2, 35.9)	12.5 (3.7, 21.3)	−12.0 (−25.1, 1.1)
High	9.9 (3.9, 15.9)	2.8 (1.0, 4.5)	−7.1[†] (−12.7, −1.6)	26.6 (12.1, 41.0)	5.3 (0.0, 10.8)	−21.2[†] (−35.8, −6.7)
χ^2	3.813	11.780		0.311	9.067	
P	0.282	0.008		0.958	0.028	
Region						
North China	15.5 (7.8, 23.3)	5.2 (0.0, 10.5)	−10.4[†] (−14.2, −6.6)	50.0 (36.6, 63.4)	13.8 (0.6, 27.1)	−36.2[†] (−56.7, −15.8)
East China	16.6 (5.6, 27.6)	7.7 (2.9, 12.4)	−9.0[†] (−17.5, −0.4)	19.1 (6.8, 31.4)	12.7 (2.6, 22.7)	−6.5 (−14.6, 1.7)
Central China	23.8 (10.9, 36.8)	6.4 (2.2, 10.5)	−17.5[†] (−31.4, −3.5)	20.9 (8.2, 33.5)	6.6 (1.3, 12.0)	−14.2[†] (−26.0, −2.4)
South China	11.6 (2.0, 21.3)	8.0 (2.7, 13.3)	−3.6 (−15.3, 8.0)	10.1 (1.3, 18.9)	0.1 (0.0, 0.3)	−10.0[†] (−19.2, −0.8)
Southwest China	10.8 (0.0, 21.8)	5.8 (0.7, 10.9)	−5.0[†] (−12.5, 2.5)	15.3 (0.7, 29.9)	7.4 (0.0, 15.8)	−7.8[†] (−16.4, 0.8)
Northwest China	15.9 (5.3, 26.6)	17.0 (4.4, 29.5)	1.0 (−10.7, 12.7)	40.9 (20.7, 61.1)	43.4 (24.5, 62.2)	2.5 (−18.2, 23.1)
Northeast China	6.1 (1.8, 10.5)	1.9 (0.9, 2.8)	−4.3[†] (−9.7, 1.2)	27.5 (15.6, 39.4)	26.0 (10.2, 41.8)	−1.5 (−16.5, 13.4)
χ^2	6.185	9.771		25.334	23.772	
P	0.403	0.135		<0.001	0.001	

Note: The difference in rate of coal use between 2014–2015 and 2019–2020 was tested using Rao−Scott χ^2.

[*] Absolute change is calculated as the prevalence in 2019 minus the prevalence in 2014.

[†] means $P<0.05$.

TABLE 5. The association of different source of solid fuels usage with chronic obstructive pulmonary disease among residents aged 40 and older in China, 2019-2020, categorized by residence.

Solid fuels usage	**Urban**		**Rural**	
	***OR* (95%*CI*)**	***P***	***OR* (95%*CI*)**	***P***
Cooking solid fuel usage				
No use(ref)	1.00		1.00	
Biomass	1.17(1.03,1.32)	0.014	0.98(0.90,1.06)	0.641
Coal	0.85(0.69,1.04)	0.105	1.05(0.90,1.21)	0.537
Biomass or Coal	1.06(0.95,1.18)	0.276	1.02(0.94,1.10)	0.636
Biomass and Coal	0.98(0.74,1.30)	0.896	1.29(1.12,1.48)	0.001
Primary solid cooking fuel usage				
No use (ref)	1.00		1.00	
Biomass	1.12(0.97,1.30)	0.115	1.00(0.92,1.08)	0.951
Coal	0.97(0.73,1.28)	0.822	1.18(1.00,1.38)	0.049
household solid fuel usage				
No use (ref)	1.00		1.00	
Biomass	1.10(0.99,1.24)	0.088	1.02(0.94,1.11)	0.663
Coal	1.04(0.92,1.18)	0.535	1.13(1.02,1.24)	0.014
Biomass or Coal	1.06(0.96,1.17)	0.250	1.04(0.96,1.13)	0.308

* The logistic regression model adjusted Age Educational level, BMI, Smoke smog exposure, Family history of lung disease, and exposure to dust or chemicals in the workplace.

Abbreviation: *OR*=odd ratio; *CI*=confidence interval.

China. The Tracking SDG7 initiative indicated a 12% global increase in access to clean cooking fuels between 2010 and 2020 (*13*). Earlier studies documented a 17% reduction in the use of solid fuels for cooking in rural areas from 2000 to 2010 (*12*). A notable decrease in the use of solid fuels for heating was primarily observed in Northern China, likely due to the initiation of clean heating initiatives (coal-to-gas/electricity conversions) beginning in 2017 (*12*).

Significantly, the use of biomass heating, particularly through increased charcoal burning, has risen in Central and South China. This trend is observed in regions where central heating is absent, with charcoal emerging as an important source of heat. However, while charcoal use contributes to $PM_{2.5}$ emissions, it also poses a significant risk of carbon monoxide (CO) poisoning (*14*). Consequently, it is imperative to prioritize understanding of health risks and to implement protective measures against CO poisoning from charcoal use.

In this study, the use of solid fuels was significantly higher in rural areas compared to urban areas, a finding that aligns with global data (*2*) and previous research (*8*). According to the WHO, in 2022, only 14% of urban populations relied on solid fuels for cooking, in contrast to 52% in rural areas (*2*). This urban-rural disparity is likely linked to the differences in fuel and technology availability and affordability (*7*,*15*). Additionally, this study identifies higher rates of solid fuels use among elderly populations, those with lower educational attainment, and regions with lower GDP per capita, which may reflect limited financial capacity and acceptance of modern, cleaner energy technologies (*6*–*7*).

This study is subject to some limitations. It exclusively analyzed households with members aged 40 years and older, potentially leading to an overestimation of the overall solid fuels use rate in China. Furthermore, the data on solid fuel use was gathered through questionnaires, which may introduce recall bias.

In China, the utilization of solid fuels for cooking and heating has substantially declined; however, significant discrepancies between urban and rural areas continue to exist. Individuals of lower socioeconomic status often display higher usage rates of solid fuels. Addressing this issue requires targeted interventions, such as enhancing infrastructure and developing sustainable clean energy systems in rural areas to increase the accessibility of clean fuels (*7*,*15*). Additionally, the implementation of health education initiatives and appropriate subsidy policies can improve both the willingness and affordability for lower socioeconomic groups to transition to clean fuels (*9,15*). It is of great public health importance to proposetargeted fuel substitution measures for various solidfuels in different regions to reduce the risk of COPD.

Conflicts of interest: No conflicts of interest.

Acknowledgements: The research personnel at local Centers for Disease Control and Prevention and hospitals for their diligent efforts in data collection.

Funding: Supported by the Science & Technology Fundamental Resources Investigation Program (Grant No. 2023FY100605), the Chinese Central Government Key Project of Public Health Program, and the National Key Research and Development Program of China (Grant No. 2016YFC1303905).

doi: 10.46234/ccdcw2024.227

Corresponding author: Liwen Fang, fangliwen@ncncd.chinacdc.cn.

---

[1] National Center for Chronic and Non-communicable Disease Control and Prevention, Chinese Center for Disease Control and Prevention, Beijing, China; [2] National Center for Women and Children's Health, Chinese Center for Disease Control and Prevention, Beijing, China.

Submitted: January 29, 2024; Accepted: April 28, 2024

REFERENCES

1. Adair-Rohani MH. WHO publishes new global data on the use of clean and polluting fuels for cooking by fuel type. 2022. https://www.who.int/news/item/20-01-2022-who-publishes-new-global-data-on-the-use-of-clean-and-polluting-fuels-for-cooking-by-fuel-type. [2022-2-24].
2. WHO. Household air pollution. 2022. https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health. [2022-12-8].
3. Wang C, Hao XY, Chen SM. Calling for improved pulmonary and critical care medicine in China and beyond. Chin Med J Pulm Crit Care Med 2023;1(1):1 – 2. https://doi.org/10.1016/j.pccm.2023.03.005.
4. Adeloye D, Song PG, Zhu YJ, Campbell H, Sheikh A, Rudan I. Global, regional, and national prevalence of, and risk factors for, chronic obstructive pulmonary disease (COPD) in 2019: a systematic review and modelling analysis. Lancet Respir Med 2022;10(5):447 – 58. https://doi.org/10.1016/S2213-2600(21)00511-7.
5. WHO. Tracking SDG7: the energy progress report 2022. 2022. https://www.who.int/publications/m/item/tracking-sdg7--the-energy-progress-report-2022. [2023-3-18].
6. Carter E, Yan L, Fu Y, Robinson B, Kelly F, Elliott P, et al. Household transitions to clean energy in a multiprovincial cohort study in China. Nat Sustain 2020;3(1):42 – 50. https://doi.org/10.1038/s41893-019-0432-x.
7. Chan KH, Lam KBH, Kurmi OP, Guo Y, Bennett D, Bian Z, et al. Trans-generational changes and rural-urban inequality in household fuel use and cookstove ventilation in China: a multi-region study of 0. 5 million adults. Int J Hyg Environ Health 2017;220(8):1370 – 81. https://doi.org/10.1016/j.ijheh.2017.09.010.
8. Duan XL, Jiang Y, Wang BB, Zhao XG, Shen GF, Cao SZ, et al. Household fuel use for cooking and heating in China: results from the first Chinese Environmental Exposure-Related Human Activity Patterns Survey (CEERHAPS). Appl Energy 2014;136:692 – 703. https://doi.org/10.1016/j.apenergy.2014.09.066.
9. Zhu X, Yun X, Meng WJ, Xu HR, Du W, Shen GF, et al. Stacked use and transition trends of rural household energy in mainland China. Environ Sci Technol 2019;53(1):521 – 9. https://doi.org/10.1021/acs.est.8b04280.
10. Fang LW, Gao P, Bao HL, Tang X, Wang BH, Feng YJ, et al. Chronic obstructive pulmonary disease in China: a nationwide prevalence study. Lancet Respir Med 2018;6(6):421 – 30. https://doi.org/10.1016/S2213-2600(18)30103-6.
11. Johnson MA, Chiang RA. Quantitative guidance for stove usage and performance to achieve health and environmental targets. Environ Health Perspect 2015;123(8):820 – 6. https://doi.org/10.1289/ehp.1408681.
12. National Development and Reform Commission, National Energy Administration, Ministry of finance of the peoples' Republic of China, Ministry of ecology and environment of the peoples' Republic of China, Ministry of Housing and urban-Rural development of the peoples' Republic of China, state-owned assets supervision administration commission of the state council, et al. Winter cleaning and heating plan in the northern region (2017-2021). 2017. 2017. http://www.gov.cn/xinwen/2017-12/20/content_5248855.htm. [2023-4-25]. (In Chinese).
13. Tang X, Liao H. Energy poverty and solid fuels use in rural China: analysis based on national population census. Energy Sustain Dev 2014;23:122 – 9. https://doi.org/10.1016/j.esd.2014.08.006.
14. Wang H. Analysis of the causes of non-occassional carbon monoxide poisoning and preliminary prevention strategies. China Pract Med 2023;18(7):134 – 7. https://doi.org/10.14163/j.cnki.11-5547/r.2023.07.037.
15. Su C, Madani H, Palm B. Heating solutions for residential buildings in China: current status and future outlook. Energy Convers Manag 2018;177:493 – 510. https://doi.org/10.1016/j.enconman.2018.10.005.

SUPPLEMENTARY TABLE S1. Rates and trends in household solid fuel use from 2014–2015 to 2019–2020 among residents aged 40 and older in China, by residence and region.

Characteristic	Household fuel*		
	2014–2015 (95% *CI*)	2019–2020 (95% *CI*)	Absolute change (%)†
Solid fuel			
Overall	55.9 (49.7, 62.0)	38.0 (31.0, 45.1)	−17.8 (−24.5, −11.2)
Residence			
Urban	39.5 (32.4, 46.7)	22.4 (15.8, 29.0)	−17.1 (−24.6, −9.6)
Rural	80.0 (74.9, 85.2)	61.1 (54.5, 67.7)	−18.9 (−25.9, −11.9)
Region			
North China	55.7 (42.1, 69.2)	18.8 (1.9, 35.7)	−36.9 (−56.4, −17.4)
East China	49.4 (34.2, 64.5)	38.5 (24.9, 52.2)	−10.8 (−20.8, −0.9)
Central China	65.6 (51.4, 79.9)	37.7 (23.3, 52.0)	−28.0 (−44.9, −11.0)
South China	53.6 (33.4, 73.9)	38.6 (20.5, 56.7)	−15.0 (−23.2, −6.8)
Southwest China	57.6 (45.4, 69.8)	44.0 (33.9, 54.1)	−13.6 (−24.5, −2.7)
Northwest China	60.8 (35.3, 86.3)	55.7 (35.3, 76.1)	−5.1 (−25.3, 15.1)
Northeast China	56.3 (36.3, 76.3)	47.5 (24.8, 70.2)	−8.8 (−20.7, 3.0)
Biomass			
Overall	37.8 (31.3, 44.3)	28.6 (22.7, 34.6)	−9.2 (−13.4, −4.9)
Residence			
Urban	22.5 (16.5, 28.6)	15.3 (10.2, 20.4)	−7.3 (−12.5, −2.0)
Rural	60.3 (52.6, 68.0)	48.4 (42.2, 54.5)	−11.9 (−19.1, −4.8)
Region			
North China	15.9 (2.7, 29.1)	10.7 (0.0, 22.3)	−5.2 (−8.7, −1.7)
East China	37.8 (25.4, 50.2)	30.0 (19.0, 41.0)	−7.7 (−17.3, 1.8)
Central China	40.6 (26.4, 54.8)	28.2 (13.4, 43.0)	−12.4 (−28.1, 3.2)
South China	45.0 (27.0, 62.9)	35.3 (17.9, 52.7)	−9.7 (−18.1, −1.3)
Southwest China	45.1 (32.7, 57.5)	36.4 (26.8, 46.0)	−8.7 (−19.1, 1.7)
Northwest China	43.0 (21.1, 65.0)	24.6 (12.8, 36.4)	−18.4 (−33.4, −3.4)
Northeast China	49.6 (31.0, 68.1)	38.5 (19.0, 58.0)	−11.1 (−22.4, 0.2)
Coal			
Overall	32.2 (25.3, 39.2)	16.6 (11.7, 21.4)	−15.7 (−22.4, −8.9)
Residence			
Urban	26.9 (20.2, 33.6)	10.9 (6.8, 15.0)	−16.0 (−22.8, −9.2)
Rural	40.2 (30.4, 50.0)	25.0 (17.9, 32.1)	−15.2 (−24.7, −5.6)
Region			
North China	51.4 (38.0, 64.9)	14.8 (1.1, 28.6)	−36.6 (−57.4, −15.8)
East China	29.6 (15.5, 43.8)	17.3 (7.1, 27.6)	−12.3 (−21.1, −3.5)
Central China	36.4 (21.0, 51.7)	11.8 (4.6, 19.1)	−24.6 (−40.0, −9.1)
South China	18.8 (4.7, 32.9)	8.1 (2.6, 13.5)	−10.7 (−25.2, 3.8)
Southwest China	18.0 (2.7, 33.4)	10.3 (1.7, 18.8)	−7.8 (−17.1, 1.6)
Northwest China	43.1 (22.7, 63.5)	45.4 (25.7, 65.1)	2.3 (−18.9, 23.6)
Northeast China	28.2 (16.3, 40.1)	26.6 (10.9, 42.4)	−1.6 (−16.5, 13.4)

* Household solid fuel use refers to the use of coal or biomass for cooking or heating.

† Absolute change equals prevalence in 2019 minus prevalence in 2014.

SUPPLEMENTARY TABLE S2. Multivariable-adjusted odds ratios for the use of solid fuels among Chinese residents aged 40 years and older, survey 2019–2020.

Fuel type/factors	**Cooking**		**Heating**		**Household***	
	***OR* (95% *CI*)**	***P***	***OR* (95%*CI*)**	***P***	***OR* (95% *CI*)**	***P***
Solid fuel						
Residence						
Urban	Ref (1.00)		Ref (1.00)		Ref (1.00)	
Rural	3.65 (2.71, 4.92)	<0.001	3.00 (1.94, 4.63)	<0.001	4.03 (2.81, 5.79)	<0.001
Age,10 years	1.28 (1.19, 1.38)	<0.001	1.08 (0.98, 1.20)	0.130	1.19 (1.10, 1.30)	<0.001
Educational level						
Primary school or below	Ref (1.00)		Ref (1.00)		Ref (1.00)	
Junior high and above	0.42 (0.35, 0.50)	<0.001	0.63 (0.47, 0.83)	0.001	0.43 (0.34, 0.53)	<0.001
GDP per capita	0.66 (0.55, 0.79)	<0.001	0.63 (0.47, 0.85)	0.002	0.61 (0.49, 0.76)	<0.001
Biomass						
Residence						
Urban	Ref (1.00)		Ref (1.00)		Ref (1.00)	
Rural	4.07 (2.96, 5.60)	<0.001	2.21 (1.29, 3.77)	0.004	3.73 (2.66, 5.22)	<0.001
Age,10 years	1.34 (1.24, 1.44)	<0.001	1.15 (1.02, 1.29)	0.024	1.29 (1.19, 1.40)	<0.001
Educational level						
Primary school or below	Ref (1.00)		Ref (1.00)		Ref (1.00)	
Junior high and above	0.41 (0.34, 0.50)	<0.001	0.40 (0.30, 0.52)	<0.001	0.38 (0.31, 0.47)	<0.001
GDP per capita	0.68 (0.56, 0.83)	<0.001	0.74 (0.56, 0.97)	0.032	0.66 (0.54, 0.80)	<0.001
Coal						
Residence						
Urban	Ref (1.00)		Ref (1.00)		Ref (1.00)	
Rural	1.38 (0.94, 2.04)	0.099	2.83 (1.69, 4.75)	<0.001	2.27 (1.45, 3.53)	<0.001
Age,10 years	1.04 (0.90, 1.19)	0.628	1.00 (0.89, 1.13)	0.956	1.00 (0.90, 1.12)	0.975
Educational level						
Primary school or below	Ref (1.00)		Ref (1.00)		Ref (1.00)	
Junior high and above	0.65 (0.50, 0.83)	0.001	1.01 (0.75, 1.36)	0.939	0.88 (0.68, 1.14)	0.332
GDP per capita	0.72 (0.56, 0.92)	0.009	0.64 (0.45, 0.92)	0.015	0.68 (0.50, 0.90)	0.009

* Household solid fuel use means that use coal or biomass for cooking or heating.

Preplanned Studies

The Association Between Preserved Ratio Impaired Spirometry and Mortality — 10 CKB Study Areas, China, 2004–2022

Yalei Ke[1]; Xinyi Zhang[1]; Dianjianyi Sun[1,2,3]; Pei Pei[2]; Huaidong Du[4]; Yiping Chen[4]; Ling Yang[4]; Xiaoming Yang[4]; Kang Wang[5]; Junshi Chen[6]; Zhengming Chen[4]; Jun Lv[1,2,3,7]; Liming Li[1,2,3]; Canqing Yu[1,2,3,#]

Summary

What is already known about this topic?

China has the world's most significant public health and economic burden of chronic respiratory disease. However, the association between preserved ratio impaired spirometry (PRISm) and mortality risk is unknown.

What is added by this report?

The PRISm group exhibited a 37% higher risk of all-cause mortality than the normal group, and the risks of death from cardiovascular diseases, neoplasms, respiratory diseases, and infectious and parasitic diseases were also increased in PRISm. Moreover, the presence of respiratory symptoms or disease was associated with an increased risk of mortality in PRISm.

What are the implications for public health practice?

It is imperative to enhance public awareness of PRISm and to implement measures to facilitate the regression of PRISm toward normal lung function.

Preserved ratio impaired spirometry (PRISm) is a non-obstructive spirometry phenotype described as a transient state associated with the progression of chronic obstructive pulmonary disease (COPD) (*1*). The prevalence of COPD is increasing in China (*2*). Previous studies excluded PRISm from respiratory studies (*3*), while recent studies on PRISm have predominantly been conducted in Western or high-income countries (*1*), leaving the significance of this lung function pattern in China uncertain. To address these gaps, this study analyzed the association between PRISm and all-cause and cause-specific mortality based on the China Kadoorie Biobank (CKB), a large-scale prospective cohort. Elevated risks of mortality from all-cause, cardiovascular, neoplastic, respiratory, and infectious and parasitic diseases were observed in PRISm, with rates comparable to those observed in obstructive spirometry. PRISm should be given more attention to avoid its progression to COPD.

The CKB, which has been reported previously (*4*), recruited 512,724 participants aged 30 to 79 from 10 areas across China at baseline from 2004 to 2008. All individuals underwent interviewer-administered questionnaires, physical measurements, and spirometry tests by trained technicians according to standard operating procedures. In the present study, participants with previously self-reported physician-diagnosed ischemic heart disease, stroke, cancer, or asthma at baseline, lost to follow-up shortly after baseline, with an FEV_1/FVC ratio >1.0, or missing data for covariates were omitted from the study, leaving 484,301 participants.

For baseline spirometry, the higher of two measurements for both FEV1 and FVC was used to calculate the FEV_1/FVC ratio. Predicted FEV_1 was calculated using the Global Lung Function Initiative 2012 equations for the Southeast Asian and Northeast Asian populations (*5*). Normal lung function was defined as an FEV_1/FVC ratio ≥0.7 and FEV_1 ≥80% predicted, PRISm as an FEV_1/FVC ratio ≥0.7 and FEV_1 <80% predicted, and obstructive spirometry as an FEV_1/FVC ratio <0.7.

Mortality data were obtained from official residential records and the Disease Surveillance Points system, supplemented by annual door-to-door investigations among those not linked to the database. Based on the International Classification of Disease, 10th Revision (ICD-10), the outcomes comprised death from all causes and cause-specific mortality, including circulatory diseases (ICD-10: I00–I99), neoplasms (C00–D48), respiratory diseases (J00–J99), infectious and parasitic diseases (A00–B99), ischemic heart disease (I20–I25), intracerebral hemorrhage (I61), ischemic stroke (I63), lung cancer (C34), COPD (J41–J44), pneumonia (J12–J18), and respiratory tuberculosis (A15–A16). Participants were censored upon death, loss to follow-up, or December 31, 2022, whichever occurred first.

Baseline variable means and prevalences were calculated for normal, PRISm, and obstructive spirometry groups using linear regression for continuous variables and logistic regression for categorical variables, adjusted for age, sex, and 10 study areas when appropriate. Mortality rates per 100,000 person-years for each group were standardized to the age structure of the 7_{th} National Population Census data (2020). For all-cause mortality, stratified Cox proportional hazards regression was used to estimate hazard ratios (*HR*s) with 95% confidence intervals (*CI*s). A proportional subdistribution hazards regression model for cause-specific mortality was fitted to account for competing risks from other causes. All analyses were stratified by age (in 5-year groups), sex, and 10 study areas, and adjusted for education, occupation, household income, marital status, alcohol consumption, smoking status, passive smoking status, physical activity levels, primary cooking and heating fuel use, consumption frequency of fresh fruits, fresh vegetables, and meat, general obesity, and abdominal obesity. The proportional hazards assumption was verified using Schoenfeld residuals. Associations between mortality and PRISm were analyzed after stratification by the presence of self-reported cough or sputum, ever-smoking, physician-diagnosed bronchitis or emphysema, and tuberculosis at baseline. Subgroup analyses were conducted across sex, age (≥60 years or not), and region (urban/rural).

Competing-risk analysis was performed using SAS (version 9.4, SAS Institute Inc, Cary, NC, USA), and all other statistical analyses were performed using R (version 4.3.1, R Foundation for Statistical Computing, Vienna, Austria). All tests were two-tailed, and $P<0.05$ were considered statistically significant.

The study included 484,301 participants with a mean age of 51.5 [standard deviation (SD)=10.5] years at baseline, 59.1% women, and 32.3% ever-smokers. At baseline, 117,210 (24.2%) had PRISm, with a mean FEV_1 % predicted of 83.9%. Compared with the normal group, individuals with PRISm or an obstructive spirometry pattern were more likely to be older, male, current or former smokers, reside in rural areas, have a lower socioeconomic level, and report poorer self-rated health status (Table 1).

During a median follow-up of 16.0 years, 73,288 deaths were documented, and the corresponding all-cause age-standardized mortality rates for normal, PRISm, and obstructive spirometry were 1,070.5, 1,574.4, and 1,943.3 per 100,000 person-years, respectively. Compared with the normal group, PRISm had a higher adjusted all-cause (*HR*=1.37, 95% *CI*: 1.35, 1.40), circulatory disease [subdistribution hazard ratio (SHR)=1.36, 95% *CI*: 1.33, 1.40], neoplasm (SHR=1.07, 95% *CI*: 1.04, 1.11), and infectious and parasitic disease (SHR=1.47, 95% *CI*: 1.24, 1.73) mortality, comparable to those observed in obstructive spirometry (Table 2). For respiratory disease mortality, the SHR in PRISm was 2.45 (95% *CI*: 2.30, 2.60), lower than those with obstructive spirometry (SHR=5.05, 95% *CI*: 4.73, 5.39). For disease-specific deaths, PRISm was associated with a higher risk of death from ischemic heart disease (SHR=1.37, 95% *CI*: 1.31, 1.42), intracerebral hemorrhage (SHR=1.31, 95% *CI*: 1.25, 1.38), ischemic stroke (SHR=1.30, 95% *CI*: 1.20, 1.40), lung cancer (SHR=1.26, 95% *CI*: 1.19, 1.34), COPD (SHR=3.06, 95% *CI*: 2.84, 3.31), pneumonia (SHR=1.47, 95% *CI*: 1.28, 1.68), and respiratory tuberculosis (SHR=2.63, 95% *CI*: 1.82, 3.82).

When stratified by respiratory symptoms of PRISm individuals, those with frequent coughing or sputum (*HR*=1.62, 95% *CI*: 1.57, 1.68) and self-reported prior bronchitis or emphysema (*HR*=1.81, 95% *CI*: 1.72, 1.91) had a much higher risk of all-cause mortality. However, the risk of all-cause mortality in the PRISm group did not appear to be substantially affected by smoking or passive smoking status (Figure 1). Analyses of sex, age, and regional subgroups of PRISm mortality risk did not show large differences (Supplementary Table S1, available at https://weekly.chinacdc.cn/).

DISCUSSION

Based on a large prospective cohort, this study explored the health effects of PRISm in the Chinese population, examining a comprehensive spectrum of mortality risks. The PRISm group exhibited a 1.4-fold higher risk of all-cause mortality. Risks of cause-specific death were also increased in the PRISm group; however, respiratory disease mortality in the PRISm group was lower than in the obstructive spirometry group, suggesting the reversibility of airflow obstruction development in PRISm. Moreover, respiratory-related symptoms and diseases were associated with an increased mortality risk, which could help identify high-risk individuals in the PRISm population.

A systematic review, including eight population-based cohort studies up to 2023, found that PRISm was associated with a 1.7-fold, 1.6-fold, and 2.0-fold increased risk of all-cause, cardiovascular, and respiratory mortality, respectively (*1*). These results were slightly higher than our findings; however, the

TABLE 1. Characteristics of China Kadoorie Biobank participants by obstruction state at baseline of 2004–2008.

Characteristics	Normal	PRISm	Obstructive spirometry
No. of participants	341,975 (70.6)	117,210 (24.2)	25,116 (5.2)
FEV_1/FVC [%, mean (SD)]	86.3 (5.8)	83.9 (5.9)	64.4 (5.8)
FEV_1 % predicted [%, mean (SD)]	96.1 (11.1)	69.8 (11.3)	62.0 (11.2)
Sociodemographic characteristics			
Age, years [mean (SD)]	50.5 (10.4)	53.0 (10.6)	58.8 (10.4)
Women	59.5	59.9	50.8
Urban	44.9	40.5	29.0
South	64.8	46.4	72.8
Education >6 years	50.4	46.1	45.1
Farmer or worker	57.5	57.9	58.7
Household income ≥20,000 yuan/year	43.9	40.3	35.7
Married	91.3	90.4	89.1
Lifestyle factors			
Ever smoking	31.8	32.8	36.3
Ever passive smoking	75.5	75.7	73.8
Currently drinking	15.3	14.7	14.2
Daily intake of fresh fruit	18.6	17.1	16.8
Daily intake of fresh vegetables	94.9	94.3	94.4
>4 days/week intake meat	47.6	46.8	43.9
Physical activity, MET-h/d [mean (SD)]	21.7 (12.2)	21.2 (12.5)	21.3 (12.3)
BMI, kg/m^2 [mean (SD)]	23.6 (3.3)	23.8 (3.4)	22.5 (3.3)
Abdominal obesity	22.2	28.3	15.8
Personal medical history			
Self-rated poor health	8.3	10.5	13.9
Hypertension	32.7	37.5	30.5
Diabetes	5.2	6.1	4.4
Emphysema or bronchitis	1.4	3.4	8.9
Frequent coughing	6.9	9.6	15.0
Frequent expectoration	6.2	8.5	13.0

Note: Values are reported as % unless otherwise indicated and adjusted for age, sex, and study areas when appropriate. All *P* values for comparisons between groups were < 0.001, except for ever passive smoking (P=0.009). Lung function category definitions: normal (FEV_1/FVC ratio ≥0.7 and FEV_1 ≥80%), PRISm (FEV_1/FVC ratio ≥0.7 and FEV_1 <80%), and obstructive spirometry (FEV_1/FVC ratio <0.7).
Abbreviation: PRISm=preserved ratio impaired spirometry; FEV_1=forced expiratory volume in one second; FVC=forced vital capacity; SD=standard deviation; MET-h/d=metabolic equivalents of task per hour per day; BMI=body mass index; CVD=cardiovascular disease.

review neglected the competing risks from other causes of death, leading to overestimation of the *HR*s. Evidence for disease-specific mortality risk is scarce due to the need for long-term follow-up and large sample sizes. Only one study reported that PRISm was associated with a 1.5-fold increased risk of death from stroke or heart disease (*6*). This study is the first to show that PRISm is associated with an increased risk of death from lung cancer, pneumonia, COPD, and respiratory tuberculosis. However, no modification effect was observed between smoking or passive smoking and the association between PRISm and mortality. Nonetheless, previous studies have shown smoking to be a strong risk factor for PRISm and its progression to airflow obstruction (*7*,*8*), suggesting that smoking cessation should be prioritized when managing PRISm to prevent premature death.

This study has several limitations. First, like other population-based epidemiologic studies (*7*,*9*), spirometry without postbronchodilator testing may overestimate the prevalence of both PRISm and obstructive spirometry. Participants with self-reported

TABLE 2. Associations of PRISm and Obstructive Spirometry with all-cause and cause-specific mortality in China Kadoorie Biobank, 2004–2022.

Cause of death	Normal	PRISm	Obstructive spirometry
All causes			
No. of deaths (mortality rate)	40,099 (1,070.5)	23,791 (1,574.4)	9,398 (1,943.3)
HR (95% *CI*)	1.00	1.37 (1.35, 1.40)	1.59 (1.56, 1.63)
Circulatory diseases			
No. of deaths (mortality rate)	16,091 (473.7)	10,916 (738.0)	3,340 (676.2)
SHR (95% *CI*)	1.00	1.36 (1.33, 1.40)	1.22 (1.18, 1.27)
Ischemic heart disease			
No. of deaths (mortality rate)	6,008 (181.1	4,254 (293.2)	1,157 (250.0)
SHR (95% *CI*)	1.00	1.37 (1.31, 1.42)	1.22 (1.14, 1.30)
Intracerebral haemorrhage			
No. of deaths (mortality rate)	3,726 (96.7)	2,938 (186.6)	881 (169.7)
SHR (95% *CI*)	1.00	1.31 (1.25, 1.38)	1.29 (1.19, 1.39)
Ischemic stroke			
No. of deaths (mortality rate)	1,808 (61.0)	1,198 (84.5)	329 (64.8)
SHR (95% *CI*)	1.00	1.30 (1.20, 1.40)	1.02 (0.90, 1.15)
Neoplasms			
No. of deaths (mortality rate)	13,982 (316.1)	6,188 (374.5)	2,231 (461.3)
SHR (95% *CI*)	1.00	1.07 (1.04, 1.11)	1.09 (1.04, 1.14)
Lung cancer			
No. of deaths (mortality rate)	3,416 (77.4)	1,843 (111.8)	692 (134.8)
SHR (95% *CI*)	1.00	1.26 (1.19, 1.34)	1.35 (1.24, 1.48)
Respiratory diseases			
No. of deaths (mortality rate)	2,013 (69.6)	2,607 (188.5)	2,389 (481.3)
SHR (95% *CI*)	1.00	2.45 (2.30, 2.60)	5.05 (4.73, 5.39)
COPD			
No. of deaths (mortality rate)	1,148 (39.6)	2,009 (146.1)	2,130 (426.8)
SHR (95% *CI*)	1.00	3.06 (2.84, 3.31)	6.81 (6.29, 7.38)
Pneumonia			
No. of deaths (mortality rate)	582 (21.2)	380 (27.6)	125 (26.7)
SHR (95% *CI*)	1.00	1.47 (1.28, 1.68)	1.32 (1.08, 1.63)
Infectious and parasitic diseases			
No. of deaths (mortality rate)	445 (10.8)	275 (16.8)	101 (22.3)
SHR (95% *CI*)	1.00	1.47 (1.24, 1.73)	1.68 (1.33, 2.11)
Respiratory tuberculosis			
No. of deaths (mortality rate)	59 (1.5)	69 (4.9)	48 (10.2)
SHR (95% *CI*)	1.00	2.63 (1.82, 3.82)	4.08 (2.69, 6.19)
Other diseases			
No. of deaths (mortality rate)	7,568 (200.3)	3,805 (256.6)	1,337 (302.2)
SHR (95% *CI*)	1.00	1.23 (1.18, 1.28)	1.15 (1.08, 1.22)

Note: The mortality rate is per 100,000 person-years and is age-standardized based on the 7th National Population Census data (2020). For cause-specific mortality, other causes of mortality were considered as competing risks, and SHRs were calculated. HRs and SHRs were stratified by age (in 5-year intervals), sex, and study areas, and adjusted for education, occupation, household income, marital status, alcohol consumption, smoking status, passive smoking status, physical activity levels, cooking and heating fuel usage, consumption frequency of fresh fruits, fresh vegetables, meat, and general and abdominal obesity. Lung function category definitions: normal (FEV_1/FVC ratio $\geq$ 0.7 and FEV_1 $\geq$80%), PRISm (FEV_1/FVC ratio $\geq$0.7 and FEV_1 <80%), and obstructive spirometry (FEV_1/FVC ratio <0.7).

Abbreviation: PRISm=preserved ratio impaired spirometry; COPD=chronic obstructive pulmonary disease; *HR*=hazard ratio; SHR=subdistribution hazard ratio; *CI*=confidence interval; FEV_1=forced expiratory volume in one second; FVC=forced vital capacity.

Status	No. of deaths	Mortality rate	*HR* (95% *CI*)
PRISm + symptoms			
Normal	40,099	1,070.5	1.00
PRISm without symptoms	19,898	1,508.7	1.33 (1.31, 1.36)
PRISm with symptoms	3,893	2,049.1	1.62 (1.57, 1.68)
PRISm + smoking*			
Normal	40,099	1,070.5	1.00
PRISm non-smoker, no passive	3,051	1,314.2	1.40 (1.35, 1.46)
PRISm non-smoker, passive	9,494	1,340.3	1.37 (1.34, 1.41)
PRISm smoker	11,246	2,004.3	1.37 (1.34, 1.40)
PRISm + bronchitis or emphysema			
Normal	40,099	1,070.5	1.00
PRISm without bronchitis or emphysema	22,367	1,548.6	1.35 (1.33, 1.38)
PRISm with bronchitis or emphysema	1,424	2,195.7	1.81 (1.72, 1.91)
PRISm + tuberculosis			
Normal	40,099	1,070.5	1.00
PRISm without tuberculosis	23,104	1,570.2	1.37 (1.35, 1.39)
PRISm with tuberculosis	687	1,842.2	1.55 (1.43, 1.67)

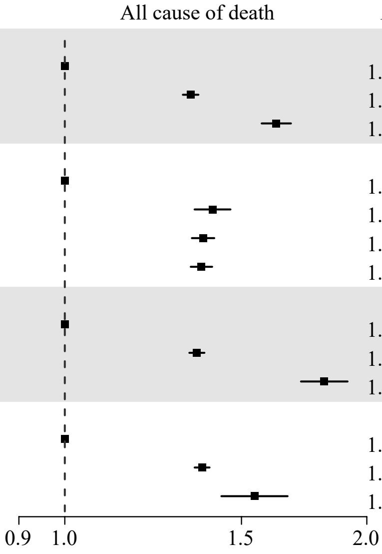


FIGURE 1. Associations of PRISm with symptoms, smoking, bronchitis or emphysema, tuberculosis at baseline with all-cause mortality in China Kadoorie Biobank, 2004–2022.

Note: The mortality rate is per 100,000 person-years and is age-standardized based on the 7th National Population Census data (2020). *HR*s were stratified by age (in 5-year intervals), sex, and study areas, and adjusted for education, occupation, household income, marital status, alcohol consumption, smoking status, passive smoking status, physical activity levels, cooking and heating fuel usage, consumption frequency of fresh fruits, fresh vegetables, meat, and general and abdominal obesity. Symptoms were defined as frequent coughing or sputum. PRISm was defined as FEV_1/FVC ratio ≥0.7 and FEV_1 <80%.

Abbreviation: PRISm=preserved ratio impaired spirometry; *HR*=hazard ratio; *CI*=confidence interval.

*PRISm individuals were grouped according to whether they never/occasionally smoked or smoked regularly, and whether they were passively exposed to smoke.

asthma at baseline were excluded to minimize such misclassification bias. Despite the potential misclassification, this study indicated that pre-bronchodilator testing is crucial and can provide significant insights, especially in resource-limited settings. Second, PRISm was employed as a single-time measurement of exposure. Given the high variability in spirometry-measured lung function observed within individuals over time (*7,10*), this study could not examine the relationship between longitudinal PRISm trajectories and mortality risk. Third, the generalization of results to other populations should be made with caution, as the CKB cohort sample is not nationally representative.

This study identified an elevated risk of all-cause and cause-specific mortality from PRISm in China, including circulatory, neoplasm, respiratory, and infectious and parasitic disease mortality. This finding indicates the necessity of enhancing public awareness of PRISm and taking action to prevent its progression to COPD.

Conflicts of interest: No conflicts of interest.

Acknowledgements: The most important acknowledgement is to the participants in the study and the members of the survey teams in each of the 10 regional centres, as well as to the project development and management teams based at Beijing, Oxford, and the 10 regional centres.

Funding: This work was supported by the National Natural Science Foundation of China (82388102, 82192900, 82192901, 82192904). The CKB baseline survey and the first re-survey were supported by a grant from the Kadoorie Charitable Foundation in Hong Kong. The long-term follow-up is supported by grants from the UK Wellcome Trust (212946/Z/18/Z, 202922/Z/16/Z, 104085/Z/14/Z, 088158/Z/09/Z), grants (2016YFC0900500) from the National Key R&D Program of China, National Natural Science Foundation of China (81390540, 91846303, 81941018), and Chinese Ministry of Science and Technology (2011BAI09B01). The funders had no role in the study design, data collection, data analysis and interpretation, writing of the report, or the decision to submit the article for publication.

doi: 10.46234/ccdcw2024.228

Corresponding author: Canqing Yu, yucanqing@pku.edu.cn.

---

[1] Department of Epidemiology and Biostatistics, School of Public Health, Peking University Health Science Center, Beijing, China;

[2] Peking University Center for Public Health and Epidemic Preparedness & Response, Beijing, China; [3] Key Laboratory of Epidemiology of Major Diseases (Peking University), Ministry of Education, Beijing, China; [4] Clinical Trial Service Unit & Epidemiological Studies Unit (CTSU), Nuffield Department of Population Health, University of Oxford, Oxford, UK; [5] Shibei Center for Disease Control and Prevention, Qingdao City, Shandong Province, China; [6] China National Center for Food Safety Risk Assessment, Beijing, China; [7] State Key Laboratory of Vascular Homeostasis and Remodeling, Peking University, Beijing, China.

Submitted: July 03, 2024; Accepted: August 15, 2024

REFERENCES

1. Yang SY, Liao GZ, Tse LA. Association of preserved ratio impaired spirometry with mortality: a systematic review and meta-analysis. Eur Respir Rev 2023;32(170):230135. https://doi.org/10.1183/16000617.0135-2023.
2. Wang C, Xu JY, Yang L, Xu YJ, Zhang XY, Bai CX, et al. Prevalence and risk factors of chronic obstructive pulmonary disease in China (the China Pulmonary Health [CPH] study): a national cross-sectional study. Lancet 2018;391(10131):1706 – 17. https://doi.org/10.1016/S0140-6736(18)30841-9.
3. Wan ES, Fortis S, Regan EA, Hokanson J, Han MK, Casaburi R, et al. Longitudinal phenotypes and mortality in preserved ratio impaired spirometry in the COPDGene study. Am J Respir Crit Care Med 2018;198(11):1397 – 405. https://doi.org/10.1164/rccm.201804-0663OC.
4. Chen ZM, Chen JS, Collins R, Guo Y, Peto R, Wu F, et al. China Kadoorie Biobank of 0. 5 million people: survey methods, baseline characteristics and long-term follow-up. Int J Epidemiol 2011;40(6):1652 – 66. https://doi.org/10.1093/ije/dyr120.
5. Quanjer PH, Stanojevic S, Cole TJ, Baur X, Hall GL, Culver BH, et al. Multi-ethnic reference values for spirometry for the 3-95-yr age range: the global lung function 2012 equations. Eur Respir J 2012;40(6):1324 – 43. https://doi.org/10.1183/09031936.00080312.
6. Shu CC, Tsai MK, Lee JH, Su TC, Wen CP. Mortality risk in patients with preserved ratio impaired spirometry: assessing the role of physical activity. QJM 2024;117(6):436 – 44. https://doi.org/10.1093/qjmed/hcae010.
7. Higbee DH, Granell R, Davey Smith G, Dodd JW. Prevalence, risk factors, and clinical implications of preserved ratio impaired spirometry: a UK Biobank cohort analysis. Lancet Respir Med 2022;10(2):149 – 57. https://doi.org/10.1016/S2213-2600(21)00369-6.
8. Washio Y, Sakata S, Fukuyama S, Honda T, Kan-O K, Shibata M, et al. Risks of mortality and airflow limitation in Japanese individuals with preserved ratio impaired spirometry. Am J Respir Crit Care Med 2022;206(5):563 – 72. https://doi.org/10.1164/rccm.202110-2302OC.
9. Wan ES, Balte P, Schwartz JE, Bhatt SP, Cassano PA, Couper D, et al. Association between preserved ratio impaired spirometry and clinical outcomes in US adults. JAMA 2021;326(22):2287 – 98. https://doi.org/10.1001/jama.2021.20939.
10. Zheng JZ, Zhou R, Zhang YC, Su KL, Chen HW, Li FR, et al. Preserved ratio impaired spirometry in relationship to cardiovascular outcomes: a large prospective cohort study. Chest 2023;163(3):610 – 23. https://doi.org/10.1016/j.chest.2022.11.003.

SUPPLEMENTARY MATERIAL

SUPPLEMENTARY TABLE S1. Subgroup analysis of PRISm with all-cause and chapter-specific mortality in China Kadoorie Biobank, 2004–2022.

Subgroup		All causes	Circulatory diseases	Neoplasms	Respiratory diseases	Infectious and parasitic diseases	Other
Sex							
Men	No. of deaths (mortality rate)	13,033 (1893.3)	5,637 (825.7)	3,711 (507.2)	1,526 (231.5)	185 (25.8)	1,974 (303.1)
	HR (95% *CI*)	1.37 (1.34, 1.40)	1.32 (1.28, 1.37)	1.11 (1.06, 1.15)	2.38 (2.20, 2.58)	1.58 (1.28, 1.93)	1.18 (1.12, 1.25)
Women	No. of deaths (mortality rate)	10,758 (1258.6)	5,279 (636.4)	2,477 (258.3)	1,081 (140.9)	90 (9.6)	1,831 (213.3)
	HR (95% *CI*)	1.37 (1.34, 1.41)	1.40 (1.35, 1.46)	1.03 (0.98, 1.08)	2.55 (2.32, 2.80)	1.29 (0.98, 1.70)	1.29 (1.21, 1.37)
Age							
<60 years	No. of deaths (mortality rate)	8,400 (569.5)	3,278 (219.3)	2,751 (184.1)	588 (38.8)	144 (10.6)	1,639 (116.7)
	HR (95% *CI*)	1.39 (1.35, 1.43)	1.56 (1.49, 1.63)	1.07 (1.02, 1.12)	3.50 (3.08, 3.98)	1.67 (1.33, 2.09)	1.37 (1.29, 1.46)
≥60 years	No. of deaths (mortality rate)	15,391 (4449.4)	7,638 (2221.9)	3,437 (919.1)	2,019 (616.5)	131 (34.8)	2,166 (657.1)
	HR (95% *CI*)	1.36 (1.33, 1.39)	1.29 (1.25, 1.33)	1.08 (1.03, 1.13)	2.15 (2.01, 2.30)	1.24 (0.98, 1.57)	1.13 (1.10, 1.20)
Region							
Urban	No. of deaths (mortality rate)	8,687 (1098.2)	3,711 (472.2)	2,685 (324.7)	752 (99.8)	83 (13.0)	1,456 (188.5)
	HR (95% *CI*)	1.34 (1.31, 1.38)	1.36 (1.30, 1.42)	1.08 (1.03, 1.13)	2.03 (1.83, 2.25)	1.31 (1.00, 1.73)	1.30 (1.21, 1.38)
Rural	No. of deaths (mortality rate)	15,104 (2192.7)	7,205 (1082.4)	3,503 (435.2)	1,855 (315.9)	192 (23.3)	2,349 (335.8)
	HR (95% *CI*)	1.39 (1.36, 1.42)	1.36 (1.32, 1.41)	1.07 (1.02, 1.11)	2.74 (2.54, 2.96)	1.56 (1.27, 1.91)	1.19 (1.13, 1.25)

Note: The mortality rate is per 100,000 person-years and is age-standardized based on the 7th National Population Census data (2020). HRs were stratified by age-at-risk (in 5-year intervals), sex, and study areas, and adjusted for education, occupation, household income, marital status, alcohol consumption, smoking status, passive smoking status, physical activity levels, cooking and heating fuel usage, and consumption frequency of fresh fruits, fresh vegetables, meat, general obesity, and abdominal obesity. For cause-specific mortality, a proportional subdistribution hazards regression model was fitted to account for competing risks from other causes.

Abbreviation: PRISm=preserved ratio impaired spirometry; HR=hazard ratio; *CI*=confidence interval.

Preplanned Studies

Prevalence and Risk Factors for Chronic Obstructive Pulmonary Disease Among Adults Aged 50 and Above
— 10 CKB Study Areas, China, 2020–2021

Wei Yu[1]; Yongbing Lan[1]; Dianjianyi Sun[1,2,3]; Pei Pei[2]; Ling Yang[4]; Yiping Chen[4]; Huaidong Du[4]; Yingcai Yang[5]; Dan Schmidt[4]; Junshi Chen[6]; Zhengming Chen[4]; Jun Lyu[1,2,3,7]; Liming Li[1,2,3]; Canqing Yu[1,2,3,#]

Summary

What is already known about this topic?

The prevalence of COPD in Chinese individuals aged 50 years and above was obviously higher than that in younger adults, but the risk factors for this age group were unclear.

What is added by this report?

The prevalence was estimated at 12.8% and 5.7% for males and females over 50 in 2020–2021, with confirmed risk factors of cigarette smoking, a family history of respiratory diseases, respiratory symptoms, and a history of cough or respiratory diseases during childhood.

What are the implications for public health practice?

The findings may help clinicians and the public identify individuals at high risk of COPD and take targeted measures in a timely manner.

In China, chronic obstructive pulmonary disease (COPD) is characterized by high prevalence, substantial economic burden, and low detection rate (*1–4*). Previous nationwide studies found that COPD prevalence was significantly higher in adults aged 50 years and older (*1–3*). However, few studies have explored the risk factors for COPD in this age group, especially lifestyle factors such as alcohol consumption and dietary intake (*5*). Moreover, sex heterogeneity is a widely validated characteristic of COPD (*6*). This study utilized data from the latest resurvey of the China Kadoorie Biobank (CKB) to assess the sex-specific risk factors for COPD among participants aged 50 years and older. The results revealed that 12.8% of males and 5.7% of females had COPD. Cigarette smoking, a family history of respiratory diseases, respiratory symptoms, a history of respiratory diseases before 18 years of age, and chronic cough until 14 years of age were positively associated with COPD, whereas being overweight and obese was inversely associated with COPD. Smoking cessation, enhancing screening or treatment for individuals with a history of respiratory symptoms or diseases during childhood or adulthood, and maintaining a healthy weight might help prevent COPD in individuals aged 50 years and older.

The CKB is a population-based prospective cohort study that included over 500,000 participants from 10 PLADs at the baseline survey during 2004–2008. In the third resurvey during 2020–2021, 25,087 participants aged 40–95 years were randomly selected, constituting approximately 5% of the baseline population. The third resurvey followed a procedure similar to the baseline survey (*7*). Two-stage lung function measurements were performed to screen for potential COPD. First, all participants without contraindications were guided to use handheld Vitalograph Pneumotrac Spirometers (Model 6800) to record at least two valid results. The highest values were used to calculate the FEV1/FVC ratio, and participants with a ratio <0.7 entered the second stage. The difference between the two stages was the inhalation of a bronchodilator before measurement in the second stage. According to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) criterion, an FEV1/FVC ratio <0.7 in the second stage (post-bronchodilator) indicated prevalent COPD (*5*). The present study included participants aged ≥50 years (*n*=24,640) and further excluded those with unsuccessful lung function tests (first stage: *n*=5,933, second stage: *n*=99) and those with missing values for key covariates (*n*=49). Finally, 6,707 males and 11,852 females were included.

Analyses were performed separately for males and females. First, COPD prevalence was calculated across sociodemographic groups (age, region, education level, and household income) using logistic regression models, to adjust for age and study area. Second, associations between lifestyle factors and COPD were explored. Based on previous studies (*8*) and data availability, the following lifestyle factors were included: smoking status, alcohol consumption, fresh fruit and red meat intake, physical activity, BMI, central obesity, passive smoking, and household air pollution. Models for each lifestyle factor were adjusted for the aforementioned sociodemographic factors and other lifestyle factors. Third, associations between respiratory factors and COPD were examined using logistic models, adjusting for all sociodemographic, lifestyle, and respiratory factors. Respiratory factors included respiratory symptoms, chronic cough until 14 years of age, a history of respiratory diseases before 18 years of age, and a family history of respiratory diseases. The multiplicative interaction between sex and each lifestyle and respiratory factor was calculated using likelihood ratio tests. All analyses were performed using Stata (version 17.0, StataCorp, College Station, TX, USA), and two-sided *P* values <0.05 were considered statistically significant.

The mean age was 65.2±8.6 years in males, of whom 900 (12.8%) had COPD. In females, the mean age was 63.8±8.3 years, and the prevalence of COPD was 648 (5.7%). Males had a higher percentage of individuals with an education level ≥ middle school and income ≥ 100,000 Chinese Yuan (CNY)/year (*P*<0.001). Notably, 54.6% of males reported daily smoking and 21.8% reported daily drinking, while only 1.7% and 1.2% of females reported these behaviors, respectively (Table 1).

COPD prevalence increased with age, with a higher prevalence observed in males than in females across all age groups. Among males, the COPD prevalence for those aged 50–59, 60–69, 70–79, and ≥80 years was 6.4%, 12.7%, 22.1%, and 25.9%, respectively. The corresponding prevalence in females was 2.1%, 5.4%, 10.2%, and 18.6%. In rural regions, the COPD prevalence was 16.1% for males and 6.9% for females, both higher than those in urban regions (9.0% for males and 3.4% for females). For participants with education levels of illiterate and primary school, middle and high school, and college or university, the respective COPD prevalence was 14.5%, 12.7%, and 4.8% for males and 5.7%, 4.9%, and 4.9% for females. COPD prevalence was also observed to decrease with increasing household income (Figure 1).

After adjusting for sociodemographic and other lifestyle factors, no significant sex difference was observed in the association between lifestyle factors and COPD (*P*>0.05). Cigarette smoking was positively associated with COPD. Compared with never-

TABLE 1. Characteristics of participants aged ≥50 in 10 CKB study areas, China, 2020–2021.

Characteristic	Overall(*n*=18,559)	Males (*n*=6,707)	Females (*n*=11,852)	*P* for sex difference
Sociodemographic characteristics				
Age, years	64.3±8.4	65.2±8.6	63.8±8.3	<0.001
Urban area, %	38.5	36.2	39.8	<0.001
Southern area, %	64.8	64.8	64.8	0.998
Middle school and higher, %	50.0	61.4	43.4	<0.001
Income ≥100,000 Chinese Yuan (CNY)/year, %	30.3	33.2	28.7	<0.001
Lifestyle factors				
Current daily smoker, %	20.8	54.6	1.7	<0.001
Passive smoker, %	71.4	63.4	76.1	<0.001
Current daily drinker, %	8.6	21.8	1.2	<0.001
Daily intake of fresh fruit, %	40.7	34.4	44.1	<0.001
Daily intake of meat, %	36.5	39.9	34.6	<0.001
Household air pollution, %	24.0	26.1	27.2	0.023
Physical activity, MET h/d	16.1±13.8	18.8±16.1	14.5±12.0	<0.001
Anthropometric measures				
BMI, kg/m^2	24.4±3.4	24.4±3.2	24.5±3.5	<0.001
Waist circumference, cm	85.8±9.4	87.6±9.4	84.7±9.2	0.116

Note: Baseline characteristics were adjusted for age and study area as appropriate. Values in the table were mean ± standard deviation for continuous variables and percentages for categorical variables.

Abbreviation: CKB=China Kadoorie Biobank; MET h/d=metabolic equivalent of task hours per day; BMI=body mass index.

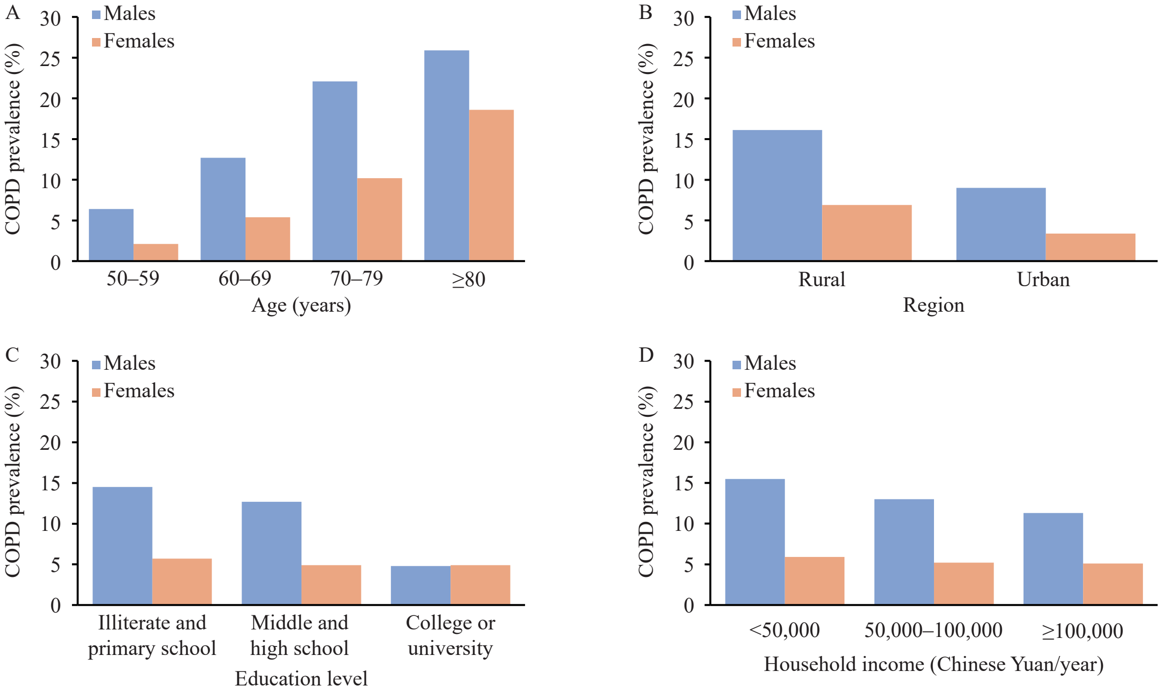


FIGURE 1. COPD prevalence in adults aged ≥50 with different characteristics in 10 CKB study areas, China, 2020–2021. (A) Age; (B) Region; (C) Education level; (D) Household income.
Abbreviation: COPD=chronic obstructive pulmonary disease; CKB=China Kadoorie Biobank.

smokers, the odds ratios [*OR*s, 95% confidence interval (*CI*s)] for current smokers with ≥15 cigarettes/d were 2.14 (1.73, 2.64) for males and 2.72 (1.14, 6.50) for females. Compared with participants with normal BMI (18.5–23.9 kg/m^2), being overweight (24.0–27.9 kg/m^2) and obese (≥28.0 kg/m^2) were negatively associated with COPD, with *OR*s (95% *CI*s) of 0.52 (0.42, 0.65) and 0.42 (0.30, 0.59) for males and 0.57 (0.45, 0.71) and 0.49 (0.35, 0.68) for females. The four respiratory factors were significantly associated with COPD. Males who had respiratory symptoms, had been hospitalized for respiratory diseases before 18 years old, had experienced frequent coughs >8 weeks until 14 years old, and had a family history of respiratory diseases were at higher risk of COPD, corresponding to *OR*s (95% *CI*s) of 1.65 (1.40, 1.95), 2.22 (1.40, 3.53), 1.96 (1.30, 2.97), and 1.80 (1.46, 2.21), respectively. For females, the *OR*s (95% *CI*s) were 1.28 (1.05, 1.56), 2.65 (1.69, 4.16), 2.28 (1.59, 3.28), and 1.42 (1.14, 1.77), respectively (Table 2).

DISCUSSION

This cross-sectional study, conducted from 2020 to 2021, explored risk factors for COPD among Chinese adults aged 50 years and older. Findings highlighted the detrimental effect of early-life respiratory injury on COPD risk. Early-life adverse exposures may stunt lung growth and predispose individuals to chronic inflammation and remodeling of the respiratory mucosa (*9*). This study provided new evidence for identifying the high-risk population for COPD, thereby effectively facilitating prevention strategies.

Compared with nationwide studies using the same definition of COPD (GOLD), the prevalence among adults aged 50 years and older in 10 CKB study areas was lower, which might be attributed to differences in survey areas and sampling methods (*1*–*3*). However, this study also revealed the high burden of COPD among Chinese adults aged 50 years and older, especially among males. Unlike other common chronic diseases, such as diabetes and cardiovascular diseases, this study and previous studies consistently indicated that being overweight and obese seems to be a protective factor for COPD (*1*,*10*). Existing literature indicates that being underweight increases COPD risk (*1*,*10*). Therefore, a healthy weight should be the primary target for general health. Regarding respiratory factors, the China Pulmonary Health study revealed that the COPD risk for participants with frequent coughs before 14 years of age increased by 1.57 times, consistent with the present study (*1*). A meta-analysis indicated that serious childhood respiratory infections, pneumonia, or bronchitis increased COPD risk, with

TABLE 2. Association between lifestyle and respiratory factors and COPD among adults aged ≥50 in 10 CKB study areas, China, 2020–2021.

Factors	Males (*n*=6,707)	Females (*n*=11,852)	*P* for sexual difference
Lifestyle factors			
Smoking status			0.152
Never	1.00	1.00	
Former	1.48 (1.11, 1.97)	3.10 (1.48, 6.48)	
Current and 1–14 cigarettes/d	1.97 (1.57, 2.47)	2.17 (1.42, 3.31)	
Current and ≥15 cigarettes/d	2.14 (1.73, 2.64)	2.72 (1.14, 6.50)	
Alcohol drinking			0.288
Non-current weekly	1.00	1.00	
Former weekly	1.06 (0.83, 1.35)	0.81 (0.47, 1.39)	
Current weekly	0.93 (0.67, 1.29)	0.42 (0.14, 1.20)	
Current daily	0.87 (0.72, 1.06)	1.11 (0.65, 1.90)	
Daily intake of fresh fruit			0.236
No	1.00	1.00	
Yes	1.03 (0.86, 1.23)	1.08 (0.89, 1.31)	
Daily intake of red meat			0.726
No	1.00	1.00	
Yes	1.15 (0.94, 1.42)	0.81 (0.64, 1.02)	
Physical activity (MET h/d)			0.514
Tertile 1	1.00	1.00	
Tertile 2	0.89 (0.73, 1.08)	0.88 (0.70, 1.09)	
Tertile 3	0.86 (0.71, 1.04)	0.97 (0.79, 1.19)	
BMI (kg/m^2)			0.916
<18.5	1.44 (0.98, 2.12)	1.47 (0.97, 2.22)	
18.5–23.9	1.00	1.00	
24.0–27.9	0.52 (0.42, 0.65)	0.57 (0.45, 0.71)	
≥28.0	0.42 (0.30, 0.59)	0.49 (0.35, 0.68)	
Central obesity			0.621
No	1.00	1.00	
Yes	1.21 (0.97, 1.52)	1.18 (0.94, 1.47)	
Passive smoking			0.617
No	1.00	1.00	
Yes	1.02 (0.86, 1.22)	1.08 (0.88, 1.33)	
Household air pollution			0.591
No	1.00	1.00	
Yes	1.06 (0.76, 1.48)	1.32 (0.84, 2.08)	
Respiratory factors			
Respiratory symptoms			0.185
No	1.00	1.00	
Yes	1.65 (1.40, 1.95)	1.28 (1.05, 1.56)	
History of respiratory diseases before 18 years old			0.571
No/don't know	1.00	1.00	
Yes	2.22 (1.40, 3.53)	2.65 (1.69, 4.16)	

Continued

Factors	Males (*n*=6,707)	Females (*n*=11,852)	*P* for sexual difference
Chronic cough until 14 years old			0.505
Rarely/don’t know	1.00	1.00	
Sometimes	1.32 (0.87, 2.00)	1.89 (1.30, 2.75)	
>8 weeks/year	1.96 (1.30, 2.97)	2.28 (1.59, 3.28)	
Family history of respiratory diseases			0.086
No	1.00	1.00	
Yes	1.80 (1.46, 2.21)	1.42 (1.14, 1.77)	

Note: Values in the table were *OR*s (95% *CI*s). For lifestyle factors, models were adjusted for age, study areas, household income, education leve in the table. For respiratory factors, models were further adjusted the respiratory factors in the table. Physical activity was divided by tertiles. Central obesity was defined as waist circumference ≥90 cm for males and ≥85 cm for females. Respiratory symptoms included coughing frequently, coughing up sputum after getting up in the morning, and wheezing or having a whistle in the chest. History of respiratory diseases before 18 years old included pneumonia, bronchitis, or tuberculosis. Family history of respiratory diseases included COPD, chronic bronchitis, emphysema, and cor pulmonale.

Abbreviation: COPD=chronic obstructive pulmonary disease; CKB=China Kadoorie Biobank; MET h/d=metabolic equivalent of task hours per day; BMI=body mass index; *OR*=odds ratio; *CI*=confidence interval.

an *OR* (95% *CI*) of 2.23 (1.63, 3.07) (*9*). Our results suggest that the critical period of COPD prevention should be shifted earlier to childhood. An integrated intervention strategy could be considered, including systematic health education for parents and targeted screening and treatment for children with respiratory symptoms or diseases.

This study has several limitations. First, the 5% survival sample of the CKB cohort is not nationally representative. Second, participants were required to have spirometry data, excluding a large proportion with unsuccessful lung function tests or missing covariates, which may have introduced selection bias. Third, the GOLD criterion may have led to overdiagnosis in older adults. Fourth, recall bias and reverse causality may be present due to the cross-sectional study design.

Our findings elucidated the risk factors of COPD for Chinese individuals aged 50 years and older. Screening for COPD using spirometry is paramount in individuals with smoking habits and a history of respiratory symptoms or diseases. Smoking cessation should be a public health priority. Our results underscore the necessity of early-life lung protection.

Conflicts of interest: No conflicts of interests.

Acknowledgements: The study participants and the members of the survey teams in each of the 10 regional centers, as well as to the project development and management teams based in Beijing, Oxford, and the 10 regional centers.

Funding: Supported by the National Natural Science Foundation of China (82388102, 82192900, 82192901, 82192904). The CKB baseline survey and the first re-survey were supported by a grant from the Kadoorie Charitable Foundation in Hong Kong. The long-term follow-up is supported by grants from the UK Wellcome Trust (212946/Z/18/Z, 202922/Z/16/Z, 104085/Z/14/Z, 088158/Z/09/Z), grants (2016YFC0900500) from the National Key R&D Program of China, National Natural Science Foundation of China (81390540, 91846303, 81941018), and Chinese Ministry of Science and Technology (2011BAI09B01).

doi: 10.46234/ccdcw2024.229

[#] Corresponding author: Canqing Yu, yucanqing@pku.edu.cn.

---

[1] Department of Epidemiology & Biostatistics, School of Public Health, Peking University, Beijing, China; [2] Peking University Center for Public Health and Epidemic Preparedness & Response, Beijing, China; [3] Key Laboratory of Epidemiology of Major Diseases (Peking University), Ministry of Education, Beijing, China; [4] Clinical Trial Service Unit & Epidemiological Studies Unit (CTSU), Nuffield Department of Population Health, University of Oxford, Oxford, United Kingdom; [5] Shinan District Center for Disease Control and Prevention, Qingdao City, Shandong Province, China; [6] China National Center for Food Safety Risk Assessment, Beijing, China; [7] State Key Laboratory of Vascular Homeostasis and Remodeling, Peking University, Beijing, China.

Submitted: June 25, 2024; Accepted: September 04, 2024

REFERENCES

1. Wang C, Xu JY, Yang L, Xu YJ, Zhang XY, Bai CX, et al. Prevalence and risk factors of chronic obstructive pulmonary disease in China (the China Pulmonary Health [CPH] study): a national cross-sectional study. Lancet 2018;391(10131):1706 – 17. https://doi.org/10.1016/S0140-6736(18)30841-9.
2. Fang LW, Gao P, Bao HL, Tang X, Wang BH, Feng YJ, et al. Chronic obstructive pulmonary disease in China: a nationwide prevalence study. Lancet Respir Med 2018;6(6):421 – 30. https://doi.org/10.1016/S2213-2600(18)30103-6.
3. Zhong NS, Wang C, Yao WZ, Chen P, Kang J, Huang SG, et al. Prevalence of chronic obstructive pulmonary disease in China: a large,

population-based survey. Am J Respir Crit Care Med 2007;176(8): 753 – 60. https://doi.org/10.1164/rccm.200612-1749OC.

4. Chen SM, Kuhn M, Prettner K, Yu FY, Yang T, Bärnighausen T, et al. The global economic burden of chronic obstructive pulmonary disease for 204 countries and territories in 2020-50: a health-augmented macroeconomic modelling study. Lancet Glob Health 2023;11(8): e1183 – 93. https://doi.org/10.1016/S2214-109X(23)00217-6.
5. Agusti, A. , Celli, B. R. , Criner, G. J. , Halpin, D. , Anzueto, A. , Barnes, P. , et al. Global Initiative for Chronic Obstructive Lung Disease 2023 Report: GOLD Executive Summary. Eur Respir 2023;61 (4):2300239 https://doi.org/10.1183/13993003.00239-2023.
6. Milne KM, Mitchell RA, Ferguson ON, Hind AS, Guenette JA. Sex-differences in COPD: from biological mechanisms to therapeutic considerations. Front Med 2024;11:1289259. https://doi.org/10.3389/fmed.2024.1289259.
7. Chen ZM, Chen JS, Collins R, Guo Y, Peto R, Wu F, et al. China Kadoorie Biobank of 0. 5 million people: survey methods, baseline characteristics and long-term follow-up. Int J Epidemiol 2011;40(6): 1652 – 66. https://doi.org/10.1093/ije/dyr120.
8. Yang IA, Jenkins CR, Salvi SS. Chronic obstructive pulmonary disease in never-smokers: risk factors, pathogenesis, and implications for prevention and treatment. Lancet Respir Med 2022;10(5):497 – 511. https://doi.org/10.1016/S2213-2600(21)00506-3.
9. Duan PF, Wang Y, Lin RQ, Zeng YM, Chen CS, Yang L, et al. Impact of early life exposures on COPD in adulthood: a systematic review and meta-analysis. Respirology 2021;26(12):1131 – 51. https://doi.org/10.1111/resp.14144.
10. Li JC, Zhu L, Wei YX, Lv J, Guo Y, Bian Z, et al. Association between adiposity measures and COPD risk in Chinese adults. Eur Respir J 2020;55(4):1901899. https://doi.org/10.1183/13993003.01899-2019.

Notifiable Infectious Diseases Reports

Reported Cases and Deaths of National Notifiable Infectious Diseases — China, August 2024*

Diseases	Cases	Deaths
Plague	2	1
Cholera	4	0
SARS-CoV	0	0
Acquired immune deficiency syndrome[†]	4,485	1,612
Hepatitis	163,748	438
Hepatitis A	1,136	0
Hepatitis B	140,045	42
Hepatitis C	19,424	395
Hepatitis D	24	0
Hepatitis E	2,597	1
Other hepatitis	522	0
Poliomyelitis	0	0
Human infection with H5N1 virus	0	0
Measles	111	0
Epidemic hemorrhagic fever	202	0
Rabies	18	19
Japanese encephalitis	16	0
Dengue	1,801	0
Anthrax	91	1
Dysentery	4,374	0
Tuberculosis	57,944	289
Typhoid fever and paratyphoid fever	550	0
Meningococcal meningitis	11	0
Pertussis	43,216	1
Diphtheria	0	0
Neonatal tetanus	2	0
Scarlet fever	2,028	0
Brucellosis	6,564	0
Gonorrhea	9,377	0
Syphilis	58,717	3
Leptospirosis	91	0
Schistosomiasis	3	0
Malaria	279	1
Human infection with H7N9 virus	0	0
Monkey pox[§]	48	0
Influenza	169,642	0
Mumps	6,692	0

Continued

Diseases	Cases	Deaths
Rubella	70	0
Acute hemorrhagic conjunctivitis	2,179	0
Leprosy	28	0
Typhus	207	0
Kala azar	34	0
Echinococcosis	335	0
Filariasis	0	0
Infectious diarrhea[¶]	144,594	1
Hand, foot and mouth disease	42,223	0
Total	719,686	2,366

[*] According to the National Bureau of Disease Control and Prevention, not included coronavirus disease 2019 (COVID-19).

[†] The number of deaths of acquired immune deficiency syndrome (AIDS) is the number of all-cause deaths reported in the month by cumulative reported AIDS patients.

[§] Since September 20, 2023, Monkey pox was included in the management of Class B infectious diseases.

[¶] Infectious diarrhea excludes cholera, dysentery, typhoid fever and paratyphoid fever.

The number of cases and cause-specific deaths refer to data recorded in National Notifiable Disease Reporting System in China, which includes both clinically-diagnosed cases and laboratory-confirmed cases. Only reported cases of the 31 provincial-level administrative divisions in the Chinese mainland are included in the table, whereas data of Hong Kong Special Administrative Region, Macau Special Administrative Region, and Taiwan, China are not included. Monthly statistics are calculated without annual verification, which were usually conducted in February of the next year for de-duplication and verification of reported cases in annual statistics. Therefore, 12-month cases could not be added together directly to calculate the cumulative cases because the individual information might be verified via National Notifiable Disease Reporting System according to information verification or field investigations by local CDCs.

doi: 10.46234/ccdcw2024.230

Youth Editorial Board

Indexed by Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI), PubMed Central (PMC), Scopus, Chinese Scientific and Technical Papers and Citations, and Chinese Science Citation Database (CSCD)

The inauguration of *China CDC Weekly* is in part supported by Project for Enhancing International Impact of China STM Journals Category D (PIIJ2-D-04-(2018)) of China Association for Science and Technology (CAST).

CCDC weekly

Vol. 6 No. 43 Oct. 25, 2024

Responsible Authority
National Disease Control and Prevention Administration

Sponsor
Chinese Center for Disease Control and Prevention

Editing and Publishing
China CDC Weekly Editorial Office
No.155 Changbai Road, Changping District, Beijing, China
Tel: 86-10-63150501, 63150701
Email: weekly@chinacdc.cn

CSSN
ISSN 2096-7071 (Print)
ISSN 2096-3101 (Online)
CN 10-1629/R1