Prevalence and risk factors of chronic obstructive pulmonary disease in China (the China Pulmonary Health [CPH] study): a national cross-sectional study

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Summary

Background **Although exposure to cigarette smoking and air pollution is common, the current prevalence of chronic obstructive pulmonary disease (COPD) is unknown in the Chinese adult population. We conducted the China Pulmonary Health (CPH) study to assess the prevalence and risk factors of COPD in China.**

Methods **The CPH study is a cross-sectional study in a nationally representative sample of adults aged 20 years or older from ten provinces, autonomous regions, and municipalities in mainland China. All participants underwent a post-bronchodilator pulmonary function test. COPD was diagnosed according to 2017 Global Initiative for Chronic Obstructive Lung Disease (GOLD) criteria.**

Findings **Between June, 2012, and May, 2015, 57 779 individuals were invited to participate, of whom 50 991 (21 446 men and 29 545 women) had reliable post-bronchodilator results and were included in the final analysis. The overall prevalence of spirometry-defined COPD was 8·6% (95% CI 7·5–9·9), accounting for 99·9 (95% CI 76·3–135·7) million people with COPD in China. Prevalence was higher in men (11·9%, 95% CI 10·2–13·8) than in women (5·4%, 4·6–6·2; p<0·0001 for sex difference) and in people aged 40 years or older (13·7%, 12·1–15·5) than in those aged 20–39 years (2·1%, 1·4–3·2; p<0·0001 for age difference). Only 12·0% (95% CI 8·1–17·4) of people with COPD reported a previous pulmonary function test. Risk factors for COPD included smoking exposure of 20 pack-years or more (odds ratio [OR] 1·95, 95% CI 1·53–2·47), exposure to annual mean particulate matter with a diameter less than 2·5 μm of 50–74 μg/m³ (1·85, 1·23–2·77) or 75 μg/m³ or higher (2·00, 1·36–2·92), underweight (body-mass index <18·5 kg/m²; 1·43, 1·03–1·97), sometimes childhood chronic cough (1·48, 1·14–1·93) or frequent cough (2·57, 2·01–3·29), and parental history of respiratory diseases (1·40, 1·23–1·60). A lower risk of COPD was associated with middle or high school education (OR 0·76, 95% CI 0·64–0·90) and college or higher education (0·47, 0·33–0·66).**

Interpretation **Spirometry-defined COPD is highly prevalent in the Chinese adult population. Cigarette smoking, ambient air pollution, underweight, childhood chronic cough, parental history of respiratory diseases, and low education are major risk factors for COPD. Prevention and early detection of COPD using spirometry should be a public health priority in China to reduce COPD-related morbidity and mortality.**

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Introduction

Chronic obstructive pulmonary disease (COPD) is a worldwide public health challenge because of its high prevalence and related disability and mortality.[1–4] The Global Burden of Disease study estimated that 174·5 million adults worldwide had prevalent COPD in 2015.[1,2] If spirometry-defined COPD is included, the disease burden could be as high as 384 million.[3] 3·2 million deaths were estimated to be due to COPD globally in 2015.[4] In China, COPD was the third leading cause of death and accounted for more than 0·9 million deaths in 2013.[5]

The most recent Chinese national survey of COPD was done during 2002–04 among 20 245 adults aged 40 years or older and reported an overall prevalence of 8·2% (12·4% in men and 5·1% in women).[6] Over the past decade, ambient air pollution has become a major public health crisis in China.[7,8] Moreover, the prevalence of cigarette smoking remains high in Chinese men.[9] Assessment of the current burden of COPD in the general Chinese population is essential for the development of public health policy and rational planning of health-care resources. Furthermore, findings of a study indicated that COPD is becoming more prevalent

Research in context

Evidence before this study

We searched PubMed and the China National Knowledge Infrastructure for articles published up to December, 2017, using the terms "chronic obstructive pulmonary disease" or "COPD" and "prevalence" and "China". We screened papers by reviewing abstracts to identify full-text reports that were relevant to the study aims. The most recent national survey of chronic obstructive pulmonary disease (COPD) in China was done during 2002–04 among 20 245 adults aged 40 years or older and reported an overall prevalence of 8·2% (12·4% in men and 5·1% in women). To the best of our knowledge, no national data for COPD prevalence in Chinese adults younger than 40 years are available.

Added value of this study

Our large, national, cross-sectional study was undertaken in a nationally representative sample of 50 991 adults from the general Chinese population. A post-bronchodilator pulmonary function test was done in all participants to diagnose COPD. Our findings indicate that, in 2015, the spirometry-defined prevalence of COPD was 8·6%, accounting for 99·9 million Chinese adults aged 20 years or older. The prevalence was 13·7% among people aged 40 years or older. For the first time, the prevalence of COPD was reported among the general population aged 20–39 years in China (2·1%). Additionally, our we showed that most people with COPD were unaware of their condition and few had received a previous pulmonary function test. Finally, cigarette smoking and heavy exposure to particulate matter with a diameter less than 2·5 μm were identified as major preventable risk factors for COPD in the Chinese adult population.

Implications of all the available evidence

Spirometry-defined COPD is highly prevalent and increasing in the Chinese adult population. Furthermore, the proportions of people with COPD who are aware of their condition or who have received pulmonary function tests are very low. Moreover, cigarette smoking and air pollution are major preventable risk factors for COPD. Our study calls for new national policy and programmes for the prevention and early detection of COPD. Specifically, health promotion for smoking cessation, control of ambient air pollution and biomass use, and screening for COPD using spirometry in high-risk individuals should be public health priorities.

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among young adults.[10] However, no national data are available for COPD prevalence in adults younger than 40 years in China.

In the China Pulmonary Health (CPH) study, we aimed to estimate the prevalence and absolute burden of COPD in the general Chinese population aged 20 years or older. Furthermore, we gathered and assessed risk factors for prevalent COPD and its awareness.

Methods

Study participants

We used a multistage stratified cluster sampling procedure to enrol a nationally representative sample of adults aged 20 years or older (appendix). In stage one, we selected ten provinces, autonomous regions, and municipalities stratified by geographical regions (only regions below an altitude of 1500 m were included). In stage two, we selected at random (using random numbers generated by SAS software) from each province or autonomous region a large city, a mid-size city, an economically developed county, and an underdeveloped county (based on being above or below the median of provincial gross domestic product). In stage three, we selected at random two urban districts from every city and two rural townships from every county. Within every municipality, we selected at random four urban districts, two rural townships from an economically developed county, and two townships from an underdeveloped county. In stage four, we selected at random two urban residential communities or rural village communities (about 1000–2000 households) from the urban districts or rural townships, respectively. In the final stage, we selected at random individuals aged 20 years or older from the selected communities. We stratified the final sampling by sex and age distribution based on 2010 China census data.[11] We selected only one participant from every household, without replacement.

We only included permanent residents (those living in their current residence for 1 year or longer) in the sampling frame. Furthermore, we excluded individuals if they were physically incapable of taking a spirometry test—ie, because of thoracic, abdominal, or eye surgery, retinal detachment, or myocardial infarction in the past 3 months; admission to hospital for any cardiac condition in the past month; heart rate greater than 120 beats per min; antibacterial chemotherapy for tuberculosis; or pregnant or breastfeeding.

The study protocol was approved by the ethics review committee of the Beijing Capital Medical University and other participating institutes. We obtained written informed consent from all study participants.

Procedures

We obtained data at local community health centres. Trained interviewers administered a standardised questionnaire including information for demographic characteristics, medical history, parental history of respiratory disease, and risk factors. We defined current smoking as having smoked 100 cigarettes in one's

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See Online for appendix

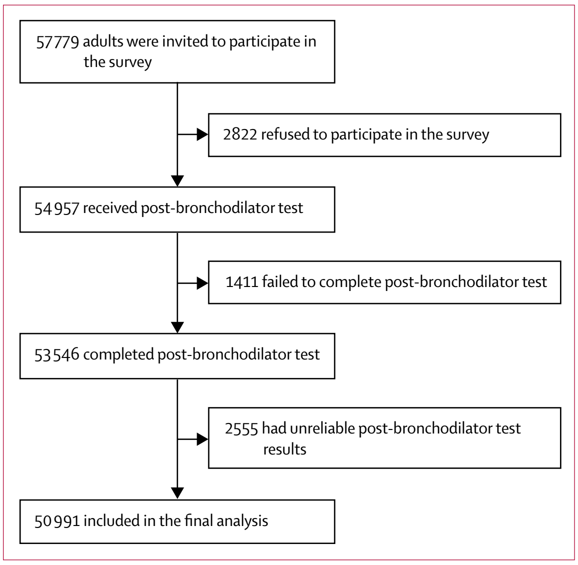

Figure 1: Flow of participants through the study

lifetime and currently smoking cigarettes. We defined passive smoking as inhalation of smoke by non-smokers who lived with smokers. We defined biomass use as using woody fuels or animal waste for cooking or heating during the past 6 months or longer. We defined history of childhood pneumonia or bronchitis as being admitted to hospital at least once for these conditions before age 14 years. We defined history of chronic bronchitis as cough and sputum production for at least 3 months in each of two consecutive years.[12] We categorised chronic cough during childhood before age 14 years as frequent (cumulative >3 months per year), sometimes (1–3 months per year), and rare (<1 month per year).

We derived exposure to ambient particulate matter with a diameter less than 2·5 µm ($PM_{2·5}$) from the regional satellite-retrieved aerosol optical depth model.[13] We assigned the modelled annual $PM_{2·5}$ concentration in every urban district or rural county in 2010 as exposure to air pollution for participants living in the area.

Trained and certified technicians did pulmonary function tests on all participants with a MasterScreen Pneumo PC spirometer (CareFusion, Yorba Linda, CA, USA). We did daily calibration with a 3 L syringe. We required participants to do up to eight forced expiratory manoeuvres until the forced vital capacity (FVC) and forced expiratory volume in 1 s (FEV_1) were reproducible within 150 mL.[14] We administered a bronchodilator (salbutamol 400 µg) by inhalation through a 500 mL spacer and repeated spirometry 20 min later, using the same criteria. We did all spirometric manoeuvres with the participant in a seated position, wearing a nose clip, and using a disposable mouthpiece. We stored test results in the spirometer and downloaded them daily to a central computer system. An expert panel did quality control based on the American Thoracic Society and European Respiratory Society criteria, and we excluded tests of poor quality.[14]

Outcomes

We defined COPD as a post-bronchodilator FEV_1:FVC ratio less than 0·70, according to 2017 Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines.[12] We calculated the ratios of observed to predicted FEV_1 based on US general population references and used them to stage the degree of obstruction (GOLD stage I, ≥80% predicted; GOLD stage II, ≥50% to <80% predicted; GOLD stage III, ≥30% to <50% predicted; and GOLD stage IV, <30% predicted).[15] Moreover, we used lower limits of normal (LLN) of Chinese reference values to define COPD in a sensitivity analysis.[16] We defined awareness of COPD as self-reported clinician-diagnosed COPD among individuals with COPD diagnosed by spirometry.

Statistical analysis

We designed the CPH study to provide reliable estimates of the prevalence of COPD for both men and women in six age groups (20–29 years, 30–39 years, 40–49 years, 50–59 years, 60–69 years, and ≥70 years) in rural and urban settings. Based on available data from previous studies, we assumed a mean COPD prevalence of 2·5% (SD 1·0) in the age group 20–39 years and 8·0% (1·5) in the 40 years or older age group. We calculated sample sizes with PASS software (NCSS, Kaysville, UT, USA).[17] Furthermore, we applied a design effect of 1·5 to account for the multistage cluster sampling design.[18] The final sample sizes were 12 516 in the age group 20–39 years and 31752 in the 40 years or older age group.

All calculations were weighted to represent the general adult population aged 20 years or older in China, according to the 2010 population census,[11] and were stratified by sampling clusters. We calculated weights using data from the 2010 population census and the study sampling scheme, and accounted for several features of the survey, including oversampling for women, non-response, and other demographic differences between the sample and the total population. Our analysis used all participants for whom the variables of interest were available. We did not impute missing data.[19] We calculated age-standardised prevalence based on 2010 China census population data. We used a technique appropriate for the complex survey design to calculate SEs. We calculated the absolute numbers of people with COPD based on the 2015 Chinese population.[20] Data are presented by age groups, sex (men *vs* women), urbanisation (urban *vs* rural), and for never-smokers, per the study protocol.

We assessed the statistical significance of differences by ANOVA for continuous variables and with the χ^2 test for categorical variables. We did multivariable logistic regression analyses to investigate risk factors for COPD

	Men						Women					
	Total (n=21 446)	No COPD (n=18 380)	GOLD stage I (n=1652)	GOLD stage II (n=1134)	GOLD stage III–IV (n=280)	p for difference	Total (n=29 545)	No COPD (n=27 703)	GOLD stage I (n=1067)	GOLD stage II (n=664)	GOLD stage III–IV (n=111)	p for difference
Proportion of participants (%)	100%	85·7%	7·7%	5·3%	1·3%	··	100%	93·8%	3·6%	2·2%	0·4%	··
Age (years)	43·6 (0·8)	41·6 (0·7)	58·3 (1·1)	59·9 (1·9)	64·7 (2·5)	<0·0001	44·0 (0·8)	43·1 (0·8)	59·8 (1·4)	59·1 (2·4)	63·5 (2·3)	<0·0001
20–39*	5980 (44·1%)	5869 (48·5%)	65 (12·4%)	40 (7·6%)	6 (7·4%)	<0·0001	6889 (43·8%)	6766 (45·6%)	50 (10·3%)	65 (14·9%)	8 (7·1%)	<0·0001
40–49	4521 (23·0%)	4184 (24·2%)	194 (14·7%)	123 (14·7%)	20 (6·5%)	··	7064 (22·6%)	6842 (23·2%)	118 (14·6%)	91 (10·3%)	13 (6·4%)	··
50–59	5298 (16·0%)	4473 (15·2%)	482 (22·4%)	286 (20·9%)	58 (18·6%)	··	8368 (15·7%)	7869 (15·6%)	318 (19·2%)	155 (16·6%)	26 (14·6%)	··
60–69	3985 (9·9%)	2906 (8·0%)	591 (24·2%)	400 (26·1%)	88 (18·6%)	··	5364 (9·8%)	4743 (9·0%)	369 (23·2%)	221 (26·1%)	31 (21·6%)	··
≥70	1662 (7·0%)	948 (4·0%)	320 (26·3%)	286 (30·7%)	108 (48·9%)	··	1860 (8·0%)	1483 (6·5%)	212 (32·8%)	132 (32·2%)	33 (50·3%)	··
Urban residents	13 572 (51·8%)	11 682 (53·3%)	1000 (37·8%)	724 (45·5%)	166 (42·3%)	0·12	19 307 (51·5%)	18 148 (52·1%)	679 (43·3%)	413 (39·5%)	67 (33·5%)	0·23
Education level												
Primary school or less	3930 (18·0%)	2818 (15·1%)	567 (41·2%)	422 (35·7%)	123 (50·7%)	<0·0001	8825 (27·2%)	7868 (25·5%)	558 (58·3%)	338 (52·2%)	61 (66·3%)	<0·0001
Middle and high school	12 732 (54·0%)	11 105 (54·5%)	906 (50·4%)	590 (52·0%)	131 (41·3%)	··	16 438 (50·7%)	15 651 (51·4%)	451 (35·8%)	294 (43·6%)	42 (27·0%)	··
College and higher	4784 (28·0%)	4457 (30·5%)	179 (8·4%)	122 (12·3%)	26 (8·0%)	··	4282 (22·1%)	4184 (23·1%)	58 (6·0%)	32 (4·2%)	8 (6·7%)	··
Smoking history												
Never-smoker	7842 (40·6%)	7052 (42·3%)	418 (28·8%)	302 (28·2%)	70 (17·6%)	<0·0001	28 587 (97·2%)	26 898 (97·6%)	991 (92·5%)	597 (88·2%)	101 (90·6%)	<0·0001
Former smoker	2626 (9·7%)	2025 (8·7%)	272 (12·6%)	232 (20·1%)	97 (37·3%)	··	212 (0·6%)	167 (0·5%)	18 (2·1%)	21 (2·4%)	6 (8·4%)	··
Current smoker	10978 (49·8%)	9303 (49·0%)	962 (58·6%)	600 (51·8%)	113 (45·1%)	··	746 (2·2%)	638 (1·9%)	58 (5·4%)	46 (9·4%)	4 (1·1%)	··
Smoking exposure (pack-years)												
0	7842 (43·6%)	7052 (45·3%)	418 (31·2%)	302 (31·2%)	70 (19·3%)	<0·0001	28 587 (97·5%)	26 898 (97·9%)	991 (93·0%)	597 (88·6%)	101 (90·7%)	<0·0001
1–9	3018 (18·2%)	2791 (19·8%)	123 (6·4%)	87 (5·7%)	17 (6·3%)	··	361 (1·0%)	322 (1·0%)	17 (1·1%)	19 (2·4%)	3 (1·2%)	
10–19	2653 (14·1%)	2318 (13·9%)	201 (18·2%)	102 (11·4%)	32 (19·7%)	··	164 (0·5%)	140 (0·4%)	14 (1·1%)	8 (0·3%)	2 (0·2%)	
≥20	6578 (24·1%)	5044 (21·0%)	811 (44·3%)	577 (51·7%)	146 (54·7%)	··	285 (1·0%)	210 (0·7%)	37 (4·8%)	34 (8·7%)	4 (7·9%)	
Passive smoking at home†	6881 (35·2%)	5872 (35·5%)	529 (31·7%)	385 (33·2%)	95 (36·1%)	0·41	16 342 (56·5%)	15 394 (56·8%)	538 (50·0%)	354 (52·6%)	56 (44·6%)	0·01
Smokers living in the home												
0	14 181 (64·8%)	12 189 (64·5%)	1085 (68·3%)	730 (66·8%)	177 (63·9%)	0·008	12 578 (43·6%)	11 731 (43·2%)	505 (50·0%)	289 (47·4%)	53 (55·4%)	0·01
1	5641 (28·9%)	4837 (29·3%)	424 (24·6%)	303 (25·9%)	77 (28·7%)	··	13 643 (46·2%)	12 840 (46·6%)	462 (42·4%)	294 (40·3%)	47 (32·5%)	··
≥2	1240 (6·3%)	1035 (6·2%)	105 (7·1%)	82 (7·4%)	18 (7·4%)	··	2699 (10·2%)	2554 (10·2%)	76 (7·6%)	60 (12·3%)	9 (12·2%)	··
Biomass use	5866 (26·4%)	4788 (24·3%)	623 (49·1%)	353 (33·7%)	112 (35·1%)	<0·0001	7762 (25·7%)	7164 (25·1%)	363 (36·5%)	202 (36·7%)	33 (35·9%)	0·0001
Annual mean $PM_{2.5}$ exposure (μg/m³)	70·2 (3·0)	69·7 (2·8)	77·0 (5·7)	70·3 (3·1)	66·2 (2·5)	0·15	71·4 (3·0)	71·3 (2·9)	74·0 (3·8)	72·6 (4·8)	67·4 (5·0)	0·005
History of tuberculosis	194 (1·7%)	142 (1·7%)	15 (1·0%)	24 (1·6%)	13 (4·8%)	0·089	146 (0·4%)	125 (0·4%)	7 (0·6%)	13 (0·7%)	1 (0·1%)	0·57
History of chronic bronchitis	743 (2·7%)	482 (2·1%)	85 (4·6%)	114 (9·4%)	62 (16·9%)	<0·0001	344 (1·0%)	264 (0·8%)	22 (2·5%)	43 (6·9%)	15 (16·0%)	<0·0001
History of pneumonia or bronchitis during childhood	1037 (5·0%)	859 (5·1%)	74 (4·1%)	80 (6·0%)	24 (5·5%)	0·32	1407 (5·3%)	1236 (5·2%)	71 (4·7%)	76 (7·4%)	24 (14·0%)	0·04
Chronic cough during childhood (age <14 years)												
Rare	18 970 (89·1%)	16 318 (89·3%)	1460 (90·1%)	961 (84·7%)	231 (89·9%)	0·003	26 126 (88·2%)	24 606 (88·5%)	908 (83·4%)	535 (83·2%)	77 (76·3%)	0·001
Sometimes	1657 (8·4%)	1413 (8·5%)	118 (7·2%)	97 (9·9%)	29 (7·8%)	··	2096 (8·6%)	1949 (8·5%)	77 (11·4%)	57 (8·3%)	13 (12·8%)	··
Frequent	535 (2·4%)	411 (2·3%)	51 (2·7%)	56 (5·4%)	17 (2·4%)	··	993 (3·2%)	849 (2·9%)	60 (5·2%)	63 (8·5%)	21 (10·9%)	··

(Table 1 continues on next page)

	Men						Women					
	Total (n=21 446)	No COPD (n=18 380)	GOLD stage I (n=1652)	GOLD stage II (n=1134)	GOLD stage III–IV (n=280)	p for difference	Total (n=29 545)	No COPD (n=27 703)	GOLD stage I (n=1067)	GOLD stage II (n=664)	GOLD stage III–IV (n=111)	p for difference
(Continued from previous page)												
Parental history of respiratory diseases	3505 (15·6%)	2850 (14·4%)	304 (23·6%)	272 (23·9%)	79 (33·7%)	<0·0001	5104 (18·1%)	4710 (18·0%)	227 (19·9%)	145 (18·5%)	22 (20·8%)	0·83
Body-mass index (kg/m^2)	24·0 (0·2)	24·1 (0·2)	23·6 (0·2)	23·6 (0·3)	22·4 (0·6)	0·02	23·2 (0·2)	23·2 (0·2)	23·8 (0·2)	23·0 (0·2)	21·4 (0·9)	0·001
FEV_1 (L)	3·4 (0·0)	3·5 (0·0)	2·8 (0·1)	2·0 (0·1)	1·1 (0·0)	<0·0001	2·5 (0·0)	2·6 (0·0)	2·0 (0·1)	1·4 (0·1)	0·8 (0·1)	<0·0001
FVC (L)	4·2 (0·0)	4·3 (0·0)	4·3 (0·1)	3·5 (0·1)	2·8 (0·1)	<0·0001	3·0 (0·0)	3·0 (0·0)	3·0 (0·1)	2·4 (0·1)	1·9 (0·1)	<0·0001
Post-bronchodilator FEV_1:FVC ratio	80·2 (0·5)	82·8 (0·3)	65·1 (0·2)	58·3 (0·5)	40·2 (1·6)	<0·0001	83·3 (0·5)	84·6 (0·3)	65·1 (0·3)	59·4 (0·4)	42·8 (1·5)	<0·0001
Self-reported diagnosed COPD	127 (0·8%)	45 (0·5%)	13 (1·1%)	24 (3·0%)	45 (16·1%)	<0·0001	71 (0·2%)	45 (0·1%)	4 (0·2%)	12 (1·6%)	10 (14·2%)	<0·0001
History of spirometry test	2240 (11·1%)	1888 (10·8%)	131 (11·0%)	151 (14·4%)	70 (23·2%)	0·06	2143 (8·3%)	1968 (8·2%)	91 (9·1%)	64 (7·9%)	20 (19·7%)	0·20

Data are weighted and expressed as number (%) or mean (SE). GOLD stage I (mild COPD): FEV_1 ≥80% predicted; GOLD stage II (moderate COPD): FEV_1 ≥50% to <80% predicted; GOLD stage III (severe COPD): FEV_1 ≥30% to <50% predicted; GOLD stage IV (very severe): FEV_1 <30% predicted. COPD=chronic obstructive pulmonary disease. FEV_1=forced expiratory volume in 1 s. FVC=forced vital capacity. GOLD=Global Initiative for Chronic Obstructive Lung Disease. $PM_{2.5}$=particulate matter with a diameter less than 2·5 μm. *Age groups 20–29 years and 30–39 years were combined because of small numbers of GOLD stage III–IV. †One or more smokers living in the same house or apartment.

Table 1: **Demographics of the general Chinese adult population aged 20 years or older in 2015, and risk factors for COPD, by GOLD stage**

in all study participants and in never-smokers separately. We did all data analyses with SUDAAN (version 11.0; Research Triangle Institute, Research Triangle Park, NC, USA) and SAS version 9.4 (SAS Institute, Cary, NC, USA).

Role of the funding source

The funder had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding authors had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

Between June, 2012, and May, 2015, 57 779 individuals (24 160 men and 33 619 women) were selected and invited to participate in the survey. 53 546 people (22 502 men and 31 044 women) completed the study (figure 1). The overall response rate was 92·7% (93·1% in men and 92·3% in women). After excluding individuals with unreliable post-bronchodilator tests, 50 991 participants (21 446 men and 29 545 women) were included in the final analysis. General characteristics and risk factors of the study population are presented in table 1, by grades of COPD. Individuals with GOLD stage III and IV were combined because of small sample sizes.

The overall prevalence of spirometry-defined COPD was 8·6% (95% CI 7·5–9·9) among the general Chinese population aged 20 years or older. Men had a higher prevalence (11·9%, 95% CI 10·2–13·8) than did women (5·4%, 4·6–6·2; p<0·0001 for sex difference). This sex difference was noted among all age groups in the general population and never-smokers (table 2). The prevalence increased with age and was 2·1% (95% CI 1·4–3·2) among individuals aged 20–39 years and 13·7% (12·1–15·5) among those aged 40 years or older in the general population (p<0·0001 for age difference). COPD prevalence was higher in rural residents (9·6%, 95% CI 8·4–10·9) than in urban residents (7·4%, 6·0–9·1; p=0·047 for urbanisation difference; table 2).

The age-standardised prevalence of COPD by GOLD stages I, II, and III–IV was, respectively, 6·9% (95% CI 5·2–9·1), 4·0% (3·4–4·6), and 1·0% (0·7–1·4) in men and 2·7% (2·4–3·0), 2·3% (1·8–2·9), and 0·4% (0·2–0·6) in women. The prevalence of LLN-defined COPD was 10·6% (95% CI 9·1–12·3) overall, 13·8% (11·4–16·7) in men, and 7·3% (6·3–8·5) in women (appendix). Main clinical symptoms by COPD stages are listed in the appendix. Roughly 39·8% of people with COPD self-reported typical symptoms of COPD, such as frequent cough, sputum, recurrent wheezing, or dyspnoea in daily life.

The estimated total number of individuals aged 20 years or older with spirometry-defined COPD in China was 99·9 million (95% CI 76·3–135·7) in 2015. Of these, 68·4 million (52·9–91·9) were men and

	Prevalence (%) in entire population (95% CI)			Prevalence (%) in never-smokers (95% CI)		
	Men	Women	Total	Men	Women	Total
Age (years)						
20–29	1·7% (0·7–3·9)	1·0% (0·6–1·8)	1·4% (0·7–2·8)	1·7% (0·6–4·7)	1·1% (0·6–1·8)	1·3% (0·6–2·7)
30–39	3·9% (2·0–7·4)	2·0% (1·2–3·3)	3·0% (1·9–4·5)	2·0% (1·0–3·9)	2·0% (1·2–3·3)	2·0% (1·4–2·8)
40–49	7·1% (5·1–9·8)	2·9% (2·1–4·1)	5·1% (3·8–6·7)	4·5% (2·6–7·5)	2·8% (2·0–4·0)	3·3% (2·3–4·8)
50–59	15·8% (12·7–19·6)	6·1% (5·1–7·4)	11·1% (9·1–13·4)	11·7% (9·5–14·5)	6·0% (5·0–7·2)	7·4% (6·3–8·8)
60–69	28·8% (24·3–33·7)	13·4% (10·3–17·4)	21·2% (17·9–25·0)	22·6% (19·1–26·6)	12·9% (10·1–16·5)	15·6% (12·9–18·8)
≥70	49·5% (41·0–58·0)	23·0% (19·8–26·4)	35·5% (29·9–41·5)	38·9% (32·5–45·6)	21·3% (17·7–25·4)	26·4% (22·8–30·3)
p for trend	<0·0001	<0·0001	<0·0001	<0·0001	<0·0001	<0·0001
Urbanisation						
Urban	10·2% (8·5–12·2)	4·6% (3·7–5·7)	7·4% (6·0–9·1)	8·0% (6·7–9·5)	4·5% (3·6–5·7)	5·5% (4·5–6·7)
Rural	13·3% (11·6–15·2)	5·9% (4·9–7·1)	9·6% (8·4–10·9)	9·6% (8·6–10·6)	5·6% (4·6–6·8)	6·7% (5·7–7·8)
p for difference	0·03	0·15	0·047	0·06	0·23	0·18
Education level						
Primary school and less	17·5% (12·7–23·6)	6·2% (5·3–7·2)	10·6% (8·6–12·9)	8·6% (7·3–10·0)	5·8% (4·9–6·9)	6·4% (5·7–7·2)
Middle and high school	11·5% (9·7–13·5)	4·6% (3·7–5·8)	8·4% (7·1–10·0)	9·4% (8·0–11·2)	4·7% (3·7–5·8)	6·2% (5·2–7·4)
College and higher	7·2% (5·8–8·9)	3·0% (2·2–4·2)	5·9% (4·8–7·1)	6·8% (5·7–8·1)	3·0% (2·1–4·1)	4·8% (4·0–5·8)
p for trend	0·003	<0·0001	0·004	0·03	<0·0001	<0·0001
Smoking history						
Never-smoker	8·8% (7·7–10·1)	5·1% (4·5–5·9)	6·2 (5·4–7·0)	..	..	..
Former smoker	11·1% (9·1–13·6)	7·8% (5·5–10·8)	10·9 (8·9–13·2)	..	..	..
Current smoker	14·1% (12·0–16·6)	8·8% (6·4–11·9)	13·7 (11·6–16·2)	..	..	..
p for trend	0·03	0·02	<0·0001	..	..	..
Smoking exposure (pack-years)						
0	8·8% (7·7–10·1)	5·1% (4·5–5·9)	6·2% (5·4–7·0)	..	..	..
1–9	7·8% (6·1–10·1)	6·2% (4·5–8·5)	7·5% (6·1–9·3)	..	..	..
10–19	13·7% (10·2–18·3)	8·9% (4·6–16·4)	13·1% (9·6–17·7)	..	..	..
≥20	15·0% (13·2–17·0)	18·5% (10·1–31·6)	14·8% (13·2–16·5)	..	..	..
p for trend	<0·0001	0·01	<0·0001	..	..	..
Smokers living in the home						
0	..	..	..	9·0% (7·7–10·6)	5·2% (4·3–6·2)	6·6% (5·6–7·9)
1	..	..	..	8·6% (6·6–11·1)	5·1% (4·2–6·2)	5·6% (4·7–6·5)
≥2	..	..	..	11·8% (6·8–19·8)	6·2% (4·5–8·4)	7·1% (5·5–9·1)
p for trend	..	..	..	0·44	0·31	0·68
Biomass use						
Yes	15·2% (12·5–18·4)	6·3% (5·5–7·3)	11·0% (9·2–13·1)	10·8% (9·4–12·4)	6·0% (5·1–7·1)	7·3% (6·3–8·3)
No	10·3% (8·8–11·9)	4·8% (4·0–5·8)	7·5% (6·4–8·6)	8·1% (6·8–9·5)	4·7% (3·9–5·6)	5·6% (4·8–6·5)
p for difference	0·009	0·02	0·007	0·01	0·05	0·02
Annual mean $PM_{2·5}$ exposure (μg/m³)						
<50	10·2% (7·7–13·4)	3·5% (2·3–5·4)	7·3% (5·3–9·9)	5·0% (3·2–7·5)	3·6% (2·3–5·4)	3·9% (3·3–4·7)
50–74	11·5% (9·3–14·1)	5·4% (4·2–6·9)	8·3% (6·8–10·0)	9·1% (7·5–10·9)	4·9% (3·9–6·1)	6·1% (5·0–7·4)
≥75	13·5% (10·6–17·0)	5·7% (4·6–7·1)	9·7% (7·6–12·2)	9·8% (7·9–12·2)	5·8% (4·6–7·3)	6·9% (5·4–8·7)
p for trend	0·17	0·03	0·18	0·005	0·03	0·003
History of tuberculosis						
Yes	13·1% (8·1–20·4)	9·5% (3·7–22·4)	11·9% (8·3–16·8)	5·3% (3·3–8·4)	7·8% (2·5–21·6)	6·9% (4·7–10·1)
No	11·9% (10·2–13·9)	5·3% (4·6–6·2)	8·6% (7·5–9·9)	8·9% (7·8–10·1)	5·1% (4·5–5·9)	6·2% (5·4–7·0)
p for difference	0·63	0·33	0·06	0·003	0·52	0·59
History of pneumonia or bronchitis during childhood						
Yes	13·2% (9·6–17·7)	9·4% (7·1–12·5)	11·3% (9·0–14·0)	6·7% (3·3–13·0)	9·2% (6·7–12·6)	8·4% (5·8–11·9)
No	11·9% (10·1–13·9)	5·2% (4·4–6·1)	8·5% (7·3–9·8)	9·0% (7·9–10·3)	5·0% (4·3–5·8)	6·1% (5·3–7·0)
p for difference	0·49	0·002	0·03	0·34	0·006	0·12

(Table 2 continues on next page)

	Prevalence (%) in entire population (95% CI)			Prevalence (%) in never-smokers (95% CI)		
	Men	Women	Total	Men	Women	Total
(Continued from previous page)						
Chronic cough during childhood (age <14 years)						
Rare	11·6% (9·7–13·8)	4·9% (4·1–5·7)	8·2% (7·0–9·6)	8·6% (7·3–10·2)	4·6% (4·0–5·3)	5·8% (5·0–6·6)
Sometimes	14·2% (11·5–17·5)	8·5% (6·3–11·3)	11·2% (9·4–13·3)	12·9% (8·1–19·9)	8·5% (6·2–11·4)	9·5% (7·5–11·9)
Frequent	18·1% (12·4–25·7)	13·2% (10·3–16·8)	15·6% (12·5–19·2)	12·7% (7·5–20·7)	13·0% (10·0–16·8)	12·7% (10·0–16·1)
p for trend	0·05	<0·0001	<0·0001	0·21	<0·0001	<0·0001
Parental history of respiratory diseases						
Yes	17·1% (12·9–22·3)	5·8% (4·9–6·9)	11·3% (9·3–13·8)	11·0% (8·1–14·8)	5·8% (4·9–6·9)	7·2% (6·0–8·5)
No	10·9% (9·6–12·4)	5·2% (4·4–6·1)	8·0% (7·0–9·2)	8·4% (7·5–9·5)	5·0% (4·3–5·7)	5·9% (5·2–6·8)
p for difference	0·001	0·12	0·0001	0·06	0·02	0·003
Body-mass index (kg/m²)						
<18·5 (underweight)	11·1% (7·1–17·2)	8·1% (5·9–10·9)	9·4% (7·1–12·4)	4·7% (1·6–13·1)	7·5% (5·5–10·3)	7·1% (5·0–9·9)
18·5–24·9 (normal weight)	13·0% (10·9–15·6)	5·7% (4·9–6·6)	9·3% (7·8–11·0)	9·2% (7·8–10·8)	5·5% (4·7–6·4)	6·5% (5·6–7·5)
25·0–29·9 (overweight)	10·1% (8·3–12·1)	4·7% (3·7–5·9)	7·4% (6·3–8·7)	8·6% (6·7–11·0)	4·4% (3·5–5·6)	5·6% (4·8–6·6)
≥30·0 (obese)	9·5% (7·4–12·1)	2·6% (1·9–3·6)	5·5% (4·3–7·0)	6·3% (3·4–11·6)	2·6% (1·9–3·6)	3·4% (2·4–4·7)
p for trend	0·33	0·0002	0·004	0·69	0·0007	0·02

COPD=chronic obstructive pulmonary disease. $PM_{2.5}$=particulate matter with a diameter less than 2·5 μm.

Table 2: **Age-specific and age-standardised prevalence of spirometry-defined COPD in the general Chinese adult population aged 20 years or older in 2015**

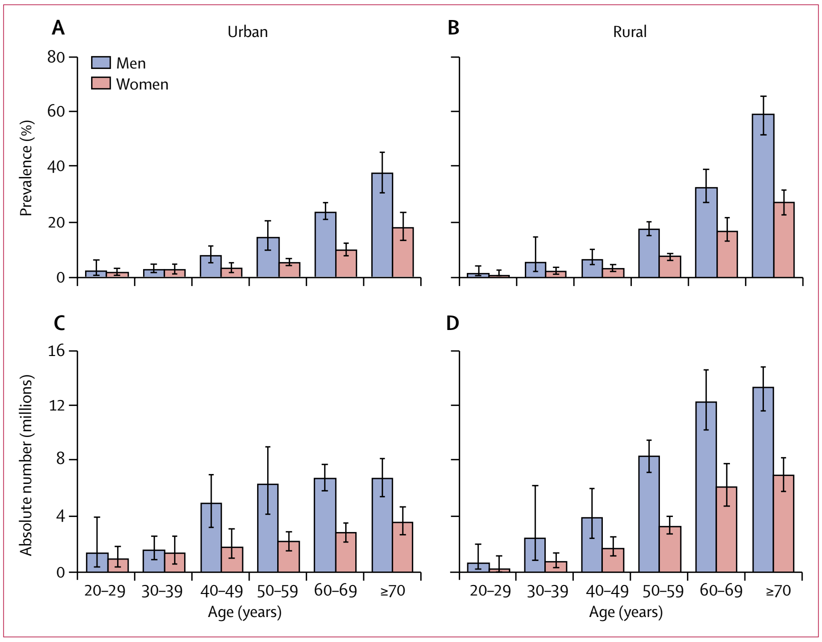

Figure 2: **Prevalence and absolute number of cases of spirometry-defined COPD in the general Chinese adult population aged 20 years or older in 2015**

Bars represent proportion or mean and error bars 95% CI. (A) Age-specific prevalence of COPD in men and women living in urban areas. (B) Age-specific prevalence of COPD in men and women living in rural areas. (C) Absolute number of cases of COPD by age in men and women living in urban areas. (D) Absolute number of cases of COPD by age in men and women living in rural areas. COPD=chronic obstructive pulmonary disease.

31·5 million (23·4–43·9) were women, and 59·7 million (47·3–78·2) were rural residents and 40·2 million (28·9–57·5) were urban residents. The absolute number of people with COPD increased with age in both urban and rural areas and in men and women (figure 2).

The age-standardised prevalence of COPD was significantly higher among current and former smokers than never-smokers (table 2). A dose-response association was noted between pack-years of cigarette smoking and prevalence of COPD in men. Associations between passive smoking and COPD were inconsistent among never-smokers. Biomass use was associated significantly with increased prevalence of COPD. Exposure to a higher level of $PM_{2.5}$ (annual mean exposure 50–74 μg/m³ and ≥75 μg/m³) was associated significantly with higher prevalence of COPD among never-smokers. Frequent cough during childhood and parental history of respiratory diseases were also associated with increased prevalence of COPD in both the general population and never-smokers. Furthermore, the age-standardised prevalence of COPD was significantly decreased among people with higher education levels (college and higher) compared with those with lower education levels (primary school or below) in the general population and never-smokers.

In multivariable-adjusted analyses, male sex, age, pack-years of smoking exposure, heavy exposure to $PM_{2.5}$ (mean annual exposure of 50–74 μg/m³ and ≥75 μg/m³), chronic cough during childhood, parental history of respiratory diseases, and underweight (body-mass index [BMI] <18·5 kg/m²) were associated significantly with risk of COPD, whereas education was associated with a lower risk (table 3). Moreover, the effect of exposure to $PM_{2.5}$ was greater among never-smokers than among the entire population.

	Entire population				Never-smokers			
	Age and sex adjusted		Multivariable adjusted*		Age and sex adjusted		Multivariable adjusted*	
	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p
Male sex	2·70 (2·24–3·26)	<0·0001	2·25 (1·83–2·77)	<0·0001	1·90 (1·64–2·19)	<0·0001	2·34 (1·99–2·75)	<0·0001
Age (every 10-year difference)	2·21 (1·99–2·46)	<0·0001	2·05 (1·84–2·27)	<0·0001	2·10 (1·84–2·39)	<0·0001	2·04 (1·72–2·42)	<0·0001
Rural resident	1·42 (1·00–2·01)	0·05	1·12 (0·80–1·56)	0·49	1·29 (0·89–1·85)	0·16	1·12 (0·76–1·63)	0·55
Smoking exposure (pack-years)								
0	1·00 (ref)	··	1·00 (ref)	··	··	··	··	··
1–9	0·85 (0·64–1·13)	0·24	0·83 (0·61–1·14)	0·23	··	··	··	··
10–19	1·85 (1·12–3·06)	0·02	1·74 (1·09–2·77)	0·02	··	··	··	··
≥20	2·17 (1·81–2·60)	<0·0001	1·95 (1·53–2·47)	<0·0001	··	··	··	··
p for trend	<0·0001	··	<0·0001	··	··	··	··	··
Smokers living in the home								
0	··	··	··	··	1·00 (ref)	··	1·00 (ref)	··
1	··	··	··	··	0·99 (0·82–1·20)	0·93	1·00 (0·81–1·23)	0·99
≥2	··	··	··	··	1·26 (0·83–1·92)	0·25	1·16 (0·80–1·69)	0·40
p for trend	··	··	··	··	0·25	··	0·44	··
Biomass use	1·62 (1·21–2·18)	0·003	1·25 (0·95–1·65)	0·10	1·42 (1·09–1·84)	0·01	1·17 (0·92–1·49)	0·19
Annual mean $PM_{2·5}$ exposure (μg/m³)								
<50	1·00 (ref)	··	1·00 (ref)	··	1·00 (ref)	··	1·00 (ref)	··
50–74	1·40 (0·82–2·36)	0·20	1·85 (1·23–2·77)	0·005	1·83 (1·31–2·56)	0·001	2·27 (1·72–2·99)	<0·0001
≥75	1·64 (0·97–2·80)	0·07	2·00 (1·36–2·92)	0·001	2·08 (1·49–2·90)	0·0002	2·34 (1·90–2·88)	<0·0001
p for trend	0·07	··	0·001	··	0·0002	··	<0·0001	··
Education level								
Primary school and lower	1·00 (ref)	··	1·00 (ref)	··	1·00 (ref)	··	1·00 (ref)	··
Middle and high school	0·67 (0·51–0·89)	0·008	0·76 (0·64–0·90)	0·003	0·81 (0·67–0·97)	0·03	0·87 (0·77–0·98)	0·03
College and higher	0·38 (0·25–0·55)	<0·0001	0·47 (0·33–0·66)	0·0002	0·49 (0·38–0·62)	<0·0001	0·52 (0·37–0·73)	0·0007
p for trend	<0·0001	··	0·0002	··	0·0001	··	0·0008	··
History of tuberculosis	0·88 (0·49–1·60)	0·67	0·55 (0·30–1·00)	0·05	0·95 (0·47–1·92)	0·87	0·82 (0·35–1·92)	0·64
History of pneumonia or bronchitis during childhood	1·40 (1·03–1·88)	0·03	0·95 (0·71–1·26)	0·69	1·39 (0·96–2·01)	0·07	0·87 (0·61–1·24)	0·41
Chronic cough during childhood (age <14 years)								
Rare	1·00 (ref)	··	1·00 (ref)	··	1·00 (ref)	··	1·00 (ref)	··
Sometimes	1·41 (1·14–1·75)	0·003	1·48 (1·14–1·93)	0·006	1·66 (1·27–2·16)	0·0009	1·75 (1·26–2·43)	0·002
Frequent	2·67 (2·01–3·55)	<0·0001	2·57 (2·01–3·29)	<0·0001	3·24 (2·57–4·08)	<0·0001	3·51 (2·80–4·40)	<0·0001
p for trend	<0·0001	··	<0·0001	··	<0·0001	··	<0·0001	··
Parental history of respiratory diseases	1·55 (1·34–1·79)	<0·0001	1·40 (1·23–1·60)	<0·0001	1·27 (1·14–1·43)	0·0003	1·20 (1·02–1·40)	0·03
Body-mass index (kg/m²)								
<18·5 (underweight)	1·19 (0·84–1·67)	0·30	1·43 (1·03–1·97)	0·03	1·29 (0·87–1·91)	0·19	1·52 (0·99–2·33)	0·06
18·5–24·9 (normal weight)	1·00 (ref)	··	1·00 (ref)	··	1·00 (ref)	··	1·00 (ref)	··
≥25 (overweight and obese)	0·71 (0·58–0·88)	0·003	0·75 (0·62–0·92)	0·01	0·79 (0·66–0·96)	0·02	0·78 (0·63–0·98)	0·03
p for trend	0·01	··	0·003	··	0·01	··	0·006	··

COPD=chronic obstructive pulmonary disease. OR=odds ratio. $PM_{2·5}$=particulate matter with a diameter less than 2·5 μm. *Including the covariables male sex, age, rural resident, smoking exposure, smokers living in the home, biomass use, annual $PM_{2·5}$ exposure, education level, history of tuberculosis, history of pneumonia or bronchitis during childhood, chronic cough during childhood, parental history of respiratory diseases, and body-mass index.

Table 3: **Multiple-adjusted ORs for COPD associated with risk factors in the general Chinese adult population aged 20 years or older in 2015**

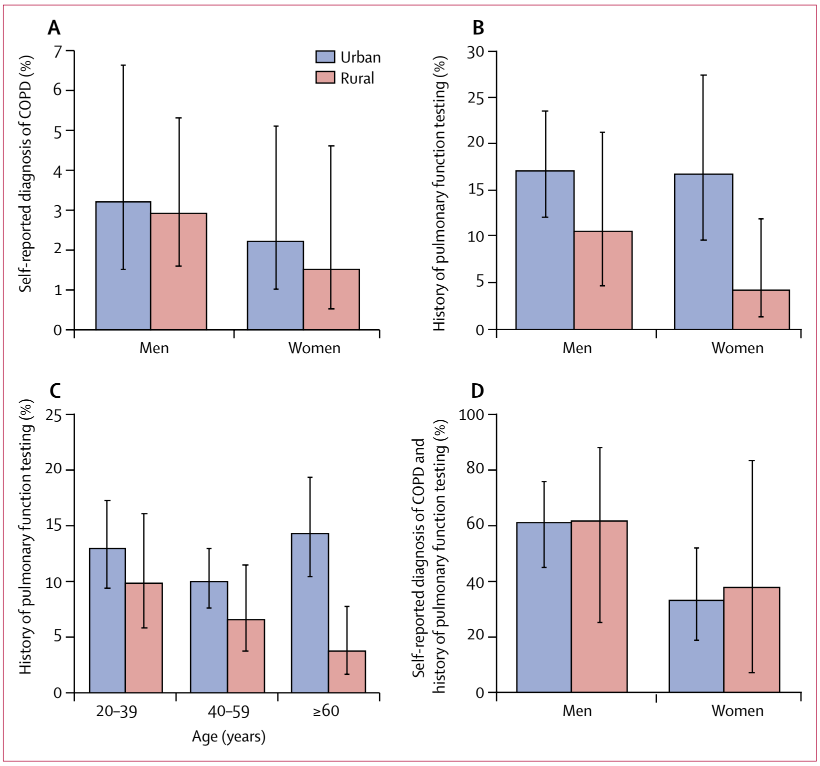

Figure 3: **Proportion of participants with self-reported diagnosis of COPD or history of pulmonary function test**
(A) Proportion with COPD who self-reported a diagnosis of COPD, by sex and urbanisation. (B) Proportion with COPD and a history of pulmonary function testing, by sex and urbanisation. (C) Proportion with COPD and a history of pulmonary function testing, by age and urbanisation. (D) Proportion with self-reported COPD and a history of pulmonary function testing, by sex and urbanisation. COPD=chronic obstructive pulmonary disease.

In a subgroup analysis, associations between risk factors and COPD were generally consistent among individuals younger than 40 years and aged 40 years and older (appendix). However, among adults younger than 40 years, parental history of respiratory diseases and heavy exposure to $PM_{2·5}$ were associated more strongly with increased prevalence of COPD whereas a reduced prevalence was associated more strongly with education level. Associations between risk factors and COPD were generally consistent among men and women and by education levels (appendix).

A significant interaction was noted between $PM_{2·5}$ exposure and cigarette smoking. Compared with never-smokers exposed to less than 50 μg/m³ $PM_{2·5}$ per year, the risk of COPD was increased (odds ratio 4·92, 95% CI 3·63–6·68) among smokers exposed to 75 μg/m³ or more $PM_{2·5}$ per year (appendix). Likewise, a significant interaction was recorded between $PM_{2·5}$ exposure and age, and $PM_{2·5}$ exposure and biomass exposure.

Among participants with spirometry-defined COPD, only 2·6% (95% CI 1·8–4·0) were aware of their condition (3·0% [1·9–4·8] of men and 1·8% [0·9–3·6] of women). Moreover, a previous pulmonary function test had been done in only 9·7% (95% CI 7·2–13·0) of the adult population (11·1% [8·7–14·2] of men and 8·3% [5·6–12·1] of women), in 12·0% (8·1–17·4) of people with COPD (13·2% [8·6–19·6] of men and 9·4% [4·7–17·8] of women), and in 55·8% (39·8–70·7) of those with a self-reported history of COPD (61·7% [38·3–80·8] of men and 35·5% [15·5–62·2] of women). The proportion of individuals with a history of pulmonary function testing was significantly higher in urban residents than in rural residents (figure 3).

Discussion

To the best of our knowledge, our study is the largest survey of COPD in a nationally representative sample of the general Chinese adult population aged 20 years and older, and our findings fill several knowledge gaps about the COPD epidemic in China. First, our data indicate that 8·6% of the general Chinese adult population (or 99·9 million Chinese adults) aged 20 years or older in 2015 had spirometry-defined COPD, reaching epidemic proportions. Second, for the first time, the prevalence of COPD has been reported among the general population aged 20–39 years in China. Third, our study findings show that most people with COPD are unaware of their condition and few have received a previous pulmonary function test. Finally, cigarette smoking and heavy exposure to $PM_{2·5}$ pollution were identified as major preventable risk factors for COPD in the Chinese population. A rigorous sampling design and stringent quality-control process ensures the validity and reliability of our study findings.

Many cross-sectional surveys have reported the prevalence of COPD in various world regions.[6,21–23] In the BOLD study,[22] which included 9425 participants from 12 countries, the prevalence of GOLD stage II or higher COPD was 10·1% overall (11·8% for men and 8·5% for women). The 2015 Global Burden of Diseases, Injuries, and Risk Factors study[2] pooled worldwide data and reported that the number of prevalent COPD cases increased by 44·2% to 174·5 million individuals from 1990 to 2015. Spirometry is the fundamental tool used to define and stage COPD in estimating population prevalence. Our study estimated that 99·9 million Chinese adults aged 20 years or older in 2015 had spirometry-defined COPD, which was significantly higher than estimates by the Global Burden of Diseases project.[2] In a meta-analysis of 123 studies, Adeloye and colleagues[3] estimated that the global prevalence of spirometry-defined COPD in adults aged 30 years or older was 11·7% (384 million cases) in 2010, an increase from 10·7% (227·3 million) in 1990. These data suggest that the global burden of COPD was underestimated in the previous report.[2]

Zhong and colleagues[6] reported that the prevalence of COPD was 8·2% among the general Chinese population aged 40 years or older in 2002–04. Our study estimated that the prevalence of COPD was 13·7% in the same age group in 2012–15, which reflects a roughly 67% increase. Although the study methods were not entirely comparable, these findings indicate that prevalence of COPD has increased rapidly and reached epidemic proportions in the general Chinese population.

Cigarette smoking is an established risk factor for COPD.[6,21–25] Our data show that smoking exposure of 20 pack-years or more is associated with a two-fold increase in the prevalence of COPD. In view of the high prevalence of cigarette smoking and COPD, smoking prevention and cessation should be important strategies for reducing COPD and the related disease burden in Chinese men. Additionally, passive smoking has been associated with COPD in epidemiological studies.[26,27] In the Guangzhou Biobank Cohort Study,[26] hours of exposure to passive smoking at home or work, but not the number of smokers living in the same household or working at the same indoor location, were associated with COPD. In our study, the number of smokers living in the same household was not associated with COPD. Our study reported a high prevalence of COPD in Chinese never-smokers. Air pollution, low education, chronic cough during childhood, parental history of respiratory diseases, and low bodyweight (BMI <25 kg/m²) might have important roles in the risk for COPD among never-smokers.

With rapid industrialisation and urbanisation, ambient air pollution has become a major public health crisis in China.[7,8] Short-term and long-term exposure to $PM_{2·5}$ is associated with risk of COPD.[28,29] In our study, heavy exposure to $PM_{2·5}$ was associated with a significant two-fold increase in prevalence of COPD in the general population and in never-smokers. The association between $PM_{2·5}$ exposure and prevalence of COPD was stronger in young adults than in middle-aged and older people. Researchers have suggested that air pollution might have greater detrimental effects on adolescent lung development than in older people.[30,31] Additionally, biomass use was associated significantly with prevalence of COPD after adjusting for age and sex. However, this association was diminished and became non-significant after full adjustment. Indoor air pollution from biomass fuels was a risk factor for COPD in other studies.[32] Heavy outdoor air pollution might mask the effect of biomass smoke in the study population.

We identified a strong protective effect of higher education on odds of COPD. Education level is an important index of socioeconomic status and access to health care. Low socioeconomic status and poor access to health care have been associated with increased risk of COPD.[33,34]

Our study findings have important public health implications. With a rapidly ageing population, high prevalence of cigarette smoking, and heavy air pollution, the burden of COPD is anticipated to continue to increase in China. In fact, COPD has become one of the three most prevalent chronic diseases (after hypertension and diabetes) in China.[35,36] Furthermore, the proportions of people with COPD who were aware of their condition or who had previously had a pulmonary function test were very low in the Chinese population. Our study calls for national policy and programmes for the prevention and early detection of COPD. Specifically, health promotion for smoking cessation and COPD prevention, control of ambient air pollution and biomass use, and screening for COPD using spirometry in high-risk individuals (eg, those aged 40 years or older who are cigarette smokers or who have a history of chronic childhood cough) should be public health priorities. Fortunately, government agencies have recommended the incorporation of pulmonary function tests into routine health examinations in China's 13th Five-Year Plan for Healthcare.[37]

Our study has several limitations. First, women were oversampled because many men (migrant workers) were working outside of their permanent residential regions. However, all estimates were weighted to correct for oversampling and non-responses in the study. Second, data for duration of exposure to passive smoking were not available, which restricted our ability to study passive smoking and COPD. Third, this cross-sectional study cannot exclude potential recall bias, such as passive smoking and previous history of COPD diagnosis. Fourth, long-term monitoring data for $PM_{2·5}$ were not available in China. Ma and colleagues[13] estimated ambient $PM_{2·5}$ concentrations in China using satellite data and reported a mean annual increase of 1·97 μg/m³ between 2004 and 2007 and a decrease of 0·46 μg/m³ between 2008 and 2013. Therefore, ambient $PM_{2·5}$ concentrations were stable during 2004–13. Fifth, airway obstruction might be underdiagnosed based merely on the fixed ratio of FEV_1:FVC among adults aged 20–45 years and overdiagnosed in elderly people. Sixth, people with asthma were not excluded from the study population, which might cause an overestimate of COPD prevalence in younger age groups. Finally, similar to other large-scale population-based surveys, the diagnosis of COPD was based only on spirometry tests done in our study. Many participants might have airflow limitation but not clinical COPD.

In conclusion, our data indicate that COPD is highly prevalent in the Chinese adult population. Cigarette smoking and air pollution are major preventable risk factors for the disease. Prevention and early detection of COPD using spirometry should be public health priorities in China, to reduce COPD-related morbidity and mortality.

Contributors

CW, JX, LY, YX, XianZ, CB, JK, PR, HS, FW, KH, WY, TS, GS, TY‡, YLi, SW, JZhu, and JH had the idea for and designed the study. CW supervised the study. GS and CS-C did the statistical analysis. All authors contributed to acquisition, analysis, or interpretation of data. CW and JH wrote the draft report. All authors revised the report and approved the final version before submission.

Declaration of interests

We declare no competing interests.

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