Prevalence of Chronic Obstructive Pulmonary Disease in China

A Large, Population-based Survey

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***Rationale*: The prevalence of chronic obstructive pulmonary disease (COPD) in China is largely unknown.**

***Objectives*: To obtain the COPD prevalence in China through a large-population, spirometry-based, cross-sectional survey of COPD.**

***Methods*: Urban and rural population-based cluster samples were randomly selected from seven provinces/cities. All residents 40 years of age or older in the selected clusters were interviewed with a standardized questionnaire revised from the international BOLD (Burden of Obstructive Lung Diseases) study. Spirometry was performed on all eligible participants. Patients with airflow limitation ($FEV_1/FVC < 0.70$) were further examined by post-bronchodilator spirometry, chest radiograph, and electrocardiogram. Post-bronchodilator FEV_1/FVC of less than 70% was defined as the diagnostic criterion of COPD.**

***Measurements and Main Results*: Among 25,627 sampling subjects, 20,245 participants completed the questionnaire and spirometry (response rate, 79.0%). The overall prevalence of COPD was 8.2% (men, 12.4%; women, 5.1%). The prevalence of COPD was significantly higher in rural residents, elderly patients, smokers, in those with lower body mass index, less education, and poor ventilation in the kitchen, in those who were exposed to occupational dusts or biomass fuels, and in those with pulmonary problems in childhood and family history of pulmonary diseases. Among the patients who had COPD, 35.3% were asymptomatic; only 35.1% reported lifetime diagnosis of bronchitis, emphysema, or other COPD; and only 6.5% have been tested with spirometry.**

***Conclusions*: COPD is prevalent in individuals 40 years of age or older in China.**

Keywords: chronic obstructive pulmonary disease; prevalence; epidemiology; cross-sectional studies; GOLD

AT A GLANCE COMMENTARY

Scientific Knowledge on the Subject

Chronic obstructive pulmonary disease is the fourth leading cause of morbidity and mortality in the United States, but its prevalence in China is largely unknown.

What This Study Adds to the Field

COPD is prevalent and underrecognized in individuals 40 years of age or older in China.

Chronic obstructive pulmonary disease (COPD) is a disease state characterized by airflow limitation that is not fully reversible (1). As a major public health problem, COPD is the fourth leading cause of morbidity and mortality in the United States, with direct and indirect medical costs up to $24 billion in 1993 (2). In China, respiratory diseases (of which COPD is a major component) are the third leading cause of death in rural areas and the fourth leading cause of death in urban areas, accounting for 1 million deaths and over 5 million disabilities each year. According to an estimation by the World Health Organization (WHO), COPD ranks first among the burdens of diseases in China and is predicted to rank as the fifth burden of diseases in the world by 2020 (3).

Earlier surveys have yielded varied global prevalence of COPD ranging from 0.23 to 18.3% because of disagreements on diagnostic criteria and epidemiologic study designs (4). In China, a previous study reported the prevalence of COPD in the northern and the central rural regions of China (Liaoning, Beijing, and Hubei province) to be 3% for individuals 15 years of age or older (5), in which only subjects with respiratory symptoms or smoking habits were recruited to receive lung function testing. Another study estimated that the prevalence of COPD was 5.9% in adults 35 years of age or older in Nanjing, China (6), based on self-reported physician diagnosis rather than spirometry. Thus, asymptomatic or never-smoking patients with COPD could have been overlooked, resulting in underestimation of the prevalence of this disease. To provide an overall prevalence of COPD in China, the present study, one of the key research projects funded by the 10th National Five-year Development Plan of China and a pertaining parallel study of Burden of Obstructive Lung Disease (BOLD), was conducted in seven provinces/cities of China between September 2002 and September 2004. To the best of our knowledge, this is the first large-scale, population-based epidemiologic study on COPD

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prevalence in China. Some results of this study have been previously orally reported in the form of an abstract at the 11th congress of the Asian Pacific Society of Respirology (7).

METHODS

Study Design and Subjects

A population-based, cross-sectional survey of COPD was conducted in seven provinces/cities in China: Beijing, Tianjin, and Liaoning (northern China); Shanghai (eastern China); Guangdong (southern China); and Shanxi and Chongqing (western China), covering a wide range of geographic areas in China and a total population of more than 230 million.

In each of these provinces/cities, we used a multistage cluster sampling strategy, in which the first stage was the stratification of census tracts. Due to the large socioeconomic differences between rural and urban regions, an urban district and a rural county were randomly selected in each province/city. As the second step of the sampling process, we randomly selected an urban street or a rural township from each of the selected urban districts and rural counties. Finally, we used a randomized cluster sampling method to select urban communities or villages (as cluster units). The number of selected clusters depended on the size of population in the communities or villages. For example, in a 20-community urban district with the average number of subjects 40 years of age or older in each community estimated to be about 300, five communities were to be selected randomly to meet the designed sample size of this study, which is 1,450. (The calculation of this sample size can be found in the online supplement). In the selected sample clusters, we recruited all residents 40 years of age or older according to the latest census by local police stations where residential registry data were kept electronically. Those temporarily out of reach were given a home interview on a later occasion. The study protocol was approved by the institutional review board of each participating center.

Data Collection

Procedures. All recruited residents were invited to participate in the study at a convenient and accessible site or at home. They were given individual interviews by our trained interviewers using a standardized questionnaire revised from the international BOLD study. The participants were made fully aware of the purpose of study, and all participants gave informed consent. After an eligibility evaluation for spirometry, the indicated subjects underwent spirometry examination. We further examined those with airflow limitation ($FEV_1/FVC < 0.70$) with post-bronchodilator spirometry, chest radiograph, and electrocardiogram. All subjects who were ineligible or who had an unsuccessful spirometry test were required to complete a short questionnaire to collect data on age, sex, and smoking status.

Spirometry and diagnostic criteria. Portable spirometers (Micro Medical Ltd, Chatham, Kent, UK) were used in the study, along with the procedure for spirometry recommended by American Thoracic Society (ATS) (8) applied to all eligible subjects (*see* the online supplement for definitions of spirometry ineligibility). Subjects with airflow limitations underwent post-bronchodilator testing at 15 to 20 minutes after inhaling a dose of 200 μg of salbutamol (Ventolin; GlaxoSmithKline, Middlesex, UK) through a 500-ml spacer. As reported by Enright and colleagues (9) (*see* online supplement), we determined a quality grade (A–F) based on acceptable maneuvers and repeatability of the FEV_1 and FVC. Spirometry results with grades A, B, or C were considered acceptable for analysis. Following the diagnostic criteria of Global Initiative for Chronic Obstructive Lung Disease (GOLD) (1), we defined subjects with post-bronchodilator FEV_1/FVC less than 70% to have COPD. Prebronchodilator FEV_1/FVC of less than 70% was used as the modified GOLD diagnostic criteria of COPD. Modified restrictive disorder was defined as prebronchodilator FEV_1/FVC of 70% or greater and FVC less than 80% predicted values. To minimize the ethnic differences between Chinese and whites, we adjusted the predicted value of FEV_1 from the reference value of the European Coal and Steel Community (1993) (ECSC93) by applying conversion factors (male by 0.95, female by 0.93) (10).

Questionnaire. The questionnaire used in this study was a revised form of the international BOLD study (11) and incorporated parts of questionnaires used in previous COPD studies in China (5). The questionnaire covered demographic data, respiratory symptoms/disease, comorbidities, health care use, activity limitation, nutritional status, potential risk factors for COPD, and the Medical Research Council dyspnea scale and health status (*see* online supplement for details) (12).

Quality control. Uniform protocol, instrument, strategies, and procedures were used among all the sites. All interviewers and spirometry operators had been well trained and accredited before the survey. A preinvestigation was conducted at each site. Before data collection, each spirometer was calibrated daily with a volume variation of less than 3% by a 3-L syringe. Spirometry results were sent every 2 weeks to Guangzhou, where the data were analyzed and quality control reports were prepared for each interviewer. All spirometry data were recorded without deletion or revision. Each completed questionnaire and spirometry report was verified by a field supervisor at the filing spot. The results were double-checked by the principal investigator and fed back to each field worker. Subjects with unacceptable measurement were invited to receive a make-up test within 30 days. All questionnaire data were coded and entered into the standardized Excel database (Microsoft, Redmond, WA) by two persons independently, with computer programs checking for out-of-range values and logic mistakes.

Statistical Analysis

The COPD prevalence was calculated as crude rates and 95% confidence intervals (CIs) and standardized for age with the reference population in the world (2000–2005) (13) and the age–sex population in the United States (2000) (14). Sex, age groups, smoking status, and other potential exposures were treated as categorical variables. The differences between the variables were determined by chi-square tests. Calculations of odd ratios (ORs) and 95% CI values for COPD in relation to potential risk factors were performed with multivariate logistic regression models. The variables of geographic area, sex, age groups, body mass index (BMI), smoking status, pack-years of smoking, occupational exposure to dusts/gases/fumes, exposure to biomass fuel for cooking or heating, ventilation in the kitchen, respiratory disease in family, pulmonary problems in childhood, and education were forced into the final multivariate logistic regression model. All statistical tests were performed with Stata statistical software (version 7.0; Stata Corporation, College Station, TX), and a P value of 0.05 was deemed significant.

RESULTS

Sample Demographics

Of 25,627 subjects sampled from seven provinces/cities, 21,270 (83.0%) were interviewed. Among 21,270 interviewees, 315 were not eligible for spirometry, 532 failed to finish the spirometry, and 20,245 completed acceptable spirometry (grades A, B, or C) and questionnaires, yielding a response rate of 79.0% (20,245/25,627) (Figure 1) (the response rate by sites is shown in Table E1 of the online supplement). The reasons for nonresponse included

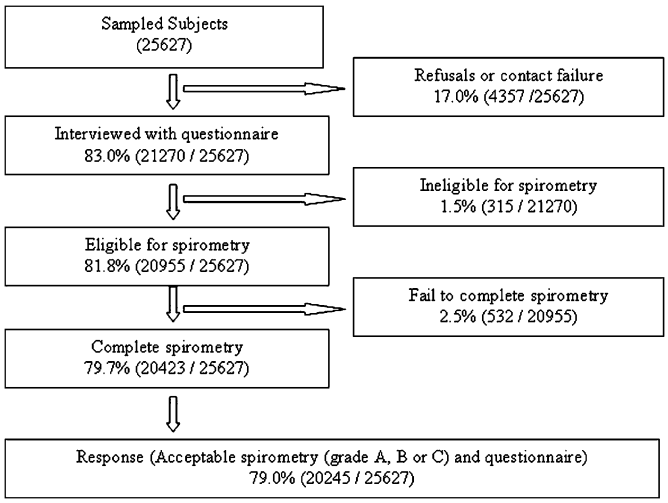

Figure 1. Response rate of questionnaire and spirometry.

refusals, contact failures, spirometry ineligibility, and failed attempts. Despite differences in age, sex, and urban/rural between responders and nonresponders, there was no significant difference in smoking status. The pattern of age and sex distribution in responders was similar to that of the whole population (Table 1). The pattern of age and sex distribution among responders, sample, and the sample frame are shown in Figure E1. The mean age of the total study population was 56.7 (SD, 11.7) years, with a range of 40 to 99 years. The percentages of current smokers, ex-smokers, and total smokers in the study population were 29.2, 9.2, and 38.4%, respectively. Smokers accounted for 74.3% of the male subjects and 11.3% of the female subjects. Those with more than 15 pack-years of smoking history added up to 25.9% of study subjects. The smoking rates of study population by urban/rural, sex, and age groups are shown in Table 2.

Prevalence of COPD

The overall prevalence of COPD in China was 8.2% (95% CI, 7.9–8.6) according to GOLD diagnostic criteria (Table 3). Standardized to the world population in 2000–2005 and to the United States population in 2000, the prevalence rates of COPD were 7.8% (95% CI, 7.4–8.1) and 8.5% (95% CI, 8.1–8.9), respectively.

The crude prevalence of COPD was the highest in Chongqing (13.7%) and lowest in Shanghai (3.9%) among urban areas and was highest in Guangdong (12.0%) and lowest in Liaoning (6.8%) and Shangxi (6.9%) among rural areas. The COPD prevalence was significantly higher in rural (8.8%) areas compared with urban areas (7.8%) ($P = 0.007$) (Table 3). According to modified GOLD diagnostic criteria (prebronchodilator $FEV_1/FVC < 70\%$), the overall prevalence of COPD in China was 11.5% (11.0–11.9%) (Table E2). The prevalence of modified restrictive disorder was 8.5% (Table E3).

Stratification Analysis on COPD Prevalence

Stratification analysis of COPD prevalence was based on demographic, social, and economic characteristics (Table 4). The prevalence of COPD was significantly higher in men than in women (12.4 vs. 5.1%; $P < 0.001$) and increased with age ($P_{trend} < 0.001$). Fewer education years were associated with a higher prevalence ($P_{trend} < 0.001$); those with a BMI of less than 18.5 kg/m^2 had a prevalence of COPD as high as 21.0%, and there was a negative correlation between BMI and COPD prevalence. For smoking status, ex-smokers were linked to higher prevalence of COPD (18.7%) compared with current smokers (11.4%) and nonsmokers (5.2%); about two-thirds (61.4%) of the patients with COPD, including 81.8% of male patients with COPD and 24.0% of female patients with COPD, were smokers (data not shown); 13.2% of smokers had COPD; hence, there was a positive correlation between smoking pack-years and COPD prevalence ($P_{trend} < 0.001$). Those with occupational exposure to dusts/gas/fumes had a higher prevalence than nonexposed subjects (9.5 vs. 7.9%; $P = 0.001$); similar results were found in those with versus those without indoor exposure to biomass (9.3 vs. 7.3%; $P < 0.001$), poor ventilation in the kitchen (9.3 vs. 7.5%; $P < 0.001$), pulmonary problems in childhood (9.3 vs. 7.9%; $P < 0.001$), and a family history of pulmonary diseases (12.1 vs. 7.2%; $P < 0.001$).

Multivariate logistic regression analyses showed that smoking, pulmonary problems in childhood, family history of respiratory diseases, male sex, low education level, aging, lower BMI, poor ventilation in the kitchen, and exposure to biomass and occupational dusts/gases/fumes are associated with COPD. Adjusted ORs (95% CI) of these potential risk factors are shown in Table 4.

TABLE 1. COMPARISON OF CHARACTERISTICS BETWEEN NONRESPONDERS AND RESPONDERS

Characteristics	Nonresponders	Responders	Sample	*P* Value*
Region				<0.001
Urban	3,526 (65.5)†	10,811 (53.4)	14,337 (55.9)	
Rural	1,856 (34.5)	9,434 (46.6)	11,290 (44.1)	
Sex				<0.001
Male	4,065 (75.5)	8,705 (43.0)	12,770 (49.8)	
Female	1,317 (24.5)	11,540 (57.0)	12,857 (50.2)	
Age, yr				<0.001
40–49	2,902 (53.9)	6,742 (33.3)	9,644 (37.6)	
50–59	1,243 (23.1)	5,517 (27.3)	6,760 (26.4)	
60+	1,237 (23.0)	7,986 (39.4)	9,223 (36.0)	
Smokers‡				0.089
Yes	414 (41.1)	7,774 (38.4)	8,188 (38.5)	
No	594 (58.9)	12,471 (61.6)	13,065 (61.5)	

* Comparison between nonresponders and responders.
† Data are given as number with percentage in parentheses.
‡ Data of nonresponses from the 1,008 participants in all sites.

Prevalence of COPD According to GOLD Severity Strata

According to the severity criteria of GOLD, the prevalence of stage I (mild), stage II (moderate), stage III (severe), and stage IV (very severe) COPD was 2.0, 3.8, 1.7, and 0.4%, respectively. Later stages of COPD were more frequent in male patients than in female patients.

The total prevalence of formerly proposed stage 0 defined by chronic cough or phlegm production with an FEV_1/FVC of 0.70 or greater was 16.1% (95% CI, 15.6–16.6) and was higher in male patients than in female patients (20.0 vs. 13.2%; $P < 0.001$) (Table 5).

Respiratory Symptoms and Lifetime Diagnosis of COPD

The prevalence of cough, phlegm, wheezing, and breathlessness respiratory symptoms in patients with COPD was 44.0%, 39.5%, 29.3%, and 48.6%, respectively (Table 6). A total of 64.7% of patients with COPD exhibited at least one of above respiratory symptoms, whereas more than one-third (35.3%) of patients with COPD were asymptomatic. The frequency of these respiratory symptoms increased with GOLD severity stages (all $P_{trend} < 0.001$). Only 35.1% of patients with COPD had ever been "diagnosed" with emphysema, asthma, bronchitis, or COPD. Of all patients with COPD, only 6.5% had ever been tested by lung function tests (spirometry).

DISCUSSION

In this large-scale population and spirometry-based, cross-sectional survey in China, the prevalence of COPD (8.2%) in people 40 years of age or older indicated COPD as a more serious public health problem in the Chinese than expected in previous studies (5, 6). The finding was close to the WHO model–estimated prevalence (6.2%) in Chinese population aged 30 years or older (15) and consistent with an expected range of 4% to 10% from international review of COPD prevalence based on spirometry (4). Compared with studies using the same diagnostic criteria (GOLD criteria) in the same age groups (adults $\geq$ 40 yr of age), our prevalence was similar to those in Japan (10.9%) (16), Poland (10.7%) (17), and Mexico City (7.8%) but was lower than those in the other four cities of Latin America (12.1–19.7%) (18) and Salzburg of Austria (26.1%) (19). Prevalence of COPD in other age groups has also been described in Korea (17.2% among subjects above 45 yr of age according to GOLD criteria) (20), Finland (9.4% among adults 20–70 yr of age according to GOLD criteria) (21), and the

TABLE 2. SMOKING STATUS OF RESPONDERS BY AGE, RURAL/URBAN AREA, AND SEX

Characteristics	Total n	Never-smokers	Ex-smokers	Current Smokers	Pack-years		
					1–14	15–29	⩾30
Rural/urban							
Urban	10,811	7,096 (65.6)*	1,151 (10.6)	2,564 (23.7)	1,282 (11.9)	1,204 (11.1)	1,229 (11.4)
Rural	9,434	5,375 (57.0)	712 (7.5)	3,347 (35.5)	1,251 (13.3)	1,343 (14.2)	1,465 (15.5)
Age, yr							
40–49	6,742	4,337 (64.3)	295 (4.4)	2,110 (31.3)	966 (14.3)	1,019 (15.1)	420 (6.2)
50–59	5,517	3,421 (62.0)	370 (6.7)	1,726 (31.3)	629 (11.4)	605 (11.0)	862 (15.6)
60–69	4,518	2,641 (58.5)	572 (12.7)	1,305 (28.9)	559 (12.4)	518 (11.5)	800 (17.7)
⩾70	3,468	2,072 (59.7%)	626 (18.1%)	770 (22.2%)	379 (10.9%)	405 (11.7%)	612 (17.6%)
Sex							
Male	8,705	2,235 (25.7%)	1,536 (17.6%)	4,934 (56.7%)	1,827 (21.0%)	2,218 (25.5%)	2,425 (27.9%)
Female	11,540	10,236 (88.7%)	327 (2.8%)	977 (8.5%)	706 (6.1%)	329 (2.9%)	269 (2.3%)
Total	20,245	12,471 (61.6%)	1,863 (9.2%)	5,911 (29.2%)	2,533 (12.5%)	2,547 (12.6%)	2,694 (13.3%)

* Data are given as number with percentage in parentheses.

United States (16.8% in residents 30–80 years of age according to modified GOLD criteria) (22). With regard to other studies, a Greek survey that was limited to smokers and used a different and more rigorous definition of COPD reported a COPD prevalence of 8.4% in people older than 35 years (23), and surveys that followed criteria of the European Respiratory Society (ERS) on spirometry (i.e., FEV_1/FVC ratio in percentage predicted $< 88\%$ in men or $< 89\%$ in women) reported a 9.1% COPD prevalence in adults 40 to 69 years of age in Spain (24) and 13.3% among subjects 35 years of age in England (25). The Northern Ireland study showed a 14.4% prevalence of COPD in subjects 40 to 69 years of age according to British Thoracic Society (BTS) criteria (26). In India, COPD was diagnosed in 4.1% of adults 35 years of age and above according to chronic bronchitis (CB) criteria (cough and expectoration for at least 3 months in a year for 2 consecutive years or more) (27). A report from Italy indicated that the prevalence of airway obstruction for subjects over 46 years was 12.2% (ERS), 28.8% (GOLD), and 57% (ATS) (28). As reported from the Obstructive Lung Disease in Northern Sweden Studies, the prevalence rates of BTS-COPD were mild, 5.3%, moderate, 2.2%, and severe, 0.6% (GOLD-COPD: mild, 8.2%; moderate, 5.3%; severe, 0.7%; and very severe, 0.1%), for subjects over 45 years of age (29).

The prevalence of COPD displays a wide range of variation due to differences in epidemiologic methodology, proportions of age and sex, response rate, and diagnostic criteria of COPD used, as described by Haibert (4, 30) and others (28, 29). Even if objective tools such as spirometry were performed in the same population, the prevalence of COPD may remain highly variable across ATS, ERS, GOLD, and BTS criteria (28, 29). Although the results of those studies cannot be directly compared with ours, they all have pinpointed COPD as a global threat to human health.

Smoking is a well-documented risk factor that contributes substantially to COPD (5, 6, 14–32). As shown in our study, about two-thirds (61.4%) of patients with COPD, including 81.8% of male patients with COPD and 24.0% of female patients with COPD, were smokers; 13.2% of smokers had COPD, and the risk for COPD increased with the number of cigarettes consumed. In contrast to other sources of data (22, 24), this study revealed higher COPD prevalence in ex-smokers than in current smokers and a higher relative OR for COPD in ex-smokers after adjusting for index of smoking and other variables. This can be explained by the lifetime bias (ex-smokers possibly had lived longer than current smokers) and the fact that majority of Chinese smokers, with poor education in tobacco control and the harmfulness of smoking to health (data not shown), have not been determined to quit smoking unless afflicted with severe diseases or old age.

About one-third (38.6%) of patients with COPD were nonsmokers, and the prevalence of COPD in nonsmokers, which was as high as 5.2%, suggested that factors other than smoking exposure might also be involved in COPD. As shown in the present study, the prevalence of COPD was significantly higher in those with lower BMI, less education, exposure to occupational dusts, and pulmonary problems in childhood, all of which are consistent with the findings of other studies (33–37). However, because some degree of recall bias might exist, more rigorous

TABLE 3. CHRONIC OBSTRUCTIVE PULMONARY DISEASE PREVALENCE ACCORDING TO GLOBAL INITIATIVE FOR CHRONIC OBSTRUCTIVE LUNG DISEASE DIAGNOSTIC CRITERIA* BY REGIONS IN CHINA

Test Sites	Urban			Rural			All Areas			*P* Values‡
	Responders (*n*)	COPD (*n*)	Prevalence† (*95% CI*)	Responders (*n*)	COPD (*n*)	Prevalence (*95% CI*)	Responders (*n*)	COPD (*n*)	Prevalence (*95% CI*)	
Beijing	1,434	98	6.8 (5.5–8.1)	1,624	148	9.1 (7.7–10.5)	3,058	246	8.0 (7.1–9.0)	0.021
Tianjin	1,500	148	9.9 (8.4–11.4)	1,508	142	9.4 (7.9–10.9)	3,008	290	9.6 (8.6–10.7)	0.676
Liaoning	1,947	157	8.1 (6.9–9.3)	2,020	138	6.8 (5.7–7.9)	3,967	295	7.4 (6.6–8.3)	0.139
Shanghai	1,503	59	3.9 (2.9–4.9)	1,516	137	9.0 (7.6–10.5)	3,019	196	6.5 (5.6–7.4)	<0.001
Guangdong	1,818	134	7.4 (6.2–8.6)	1,468	176	12.0 (10.3–13.7)	3,286	310	9.4 (8.4–10.4)	<0.001
Shanxi	1,189	47	4.0 (2.8–5.1)	1,298	89	6.9 (5.5–8.2)	2,487	136	5.5 (4.6–6.4)	0.001
Chongqing	1,420	195	13.7 (11.9–15.5)	—	—	—	1,420	195	13.7 (11.9–15.5)	
Total	10,811	838	7.8 (7.2–8.3)	9,434	830	8.8 (8.2–8.4)	20,245	1668	8.2 (7.9–8.6)	0.007

Definition of abbreviations: CI = confidence interval; COPD = chronic obstructive pulmonary disease.

* Post-bronchodilator $FEV_1/FVC < 70\%$ was defined as COPD according to Global Initiative for Chronic Obstructive Lung Disease diagnostic criteria.

† Prevalence values are given as percentage with 95% CIs in parentheses.

‡ Comparison between urban and rural with COPD prevalence.

TABLE 4. STRATIFICATION ANALYSIS OF CHRONIC OBSTRUCTIVE PULMONARY DISEASE* PREVALENCE IN CHINA BY DEMOGRAPHIC, SOCIAL, AND ECONOMIC CHARACTERISTICS

		COPD			Adjusted OR
	Responders (*n*)	*n*	% (*95% CI*)	*P* Value	(*95% CI*)
Area				0.007	
Urban	10,811	838	7.8 (7.2–8.3)		1.00 (reference)
Rural	9,434	830	8.8 (8.2–8.4)		1.30 (1.07–1.57)
Sex				<0.001	
Male	8,705	1,080	12.4 (11.7–13.1)		1.85 (1.59–2.14)
Female	11,540	588	5.1 (4.7–5.5)		1.00 (reference)
Age, yr				<0.001‡	
40–49	6,742	153	2.3 (1.9–2.6)		1.00 (reference)
50–59	5,517	278	5.0 (4.5–5.6)		2.01 (1.64–2.48)
60–69	4,518	530	11.7 (10.8–12.7)		4.97 (4.09–6.04)
⩾70	3,468	707	20.4 (19.0–21.7)		9.20 (7.48–11.30)
Education, yr				<0.001‡	
0	3,824	496	13.0 (11.9–14.0)		1.94 (1.47–2.57)
1–5	5,120	529	10.3 (9.5–11.2)		1.38 (1.07–1.79)
6–8	5,823	361	6.2 (5.6–6.8)		1.31 (1.02–1.69)
9–11	3,944	188	4.8 (4.1–5.4)		1.14 (0.87–1.50)
⩾12	1,534	94	6.1 (4.9–7.3)		1.00 (reference)
BMI, kg/m^2				<0.001‡	
<18.5	790	166	21.0 (18.2–23.9)		3.70 (2.83–4.85)
18.5–23.9	9,918	942	9.5 (8.9–10.1)		1.73 (1.41–2.11)
24.0–27.9	7,185	433	6.0 (5.5–6.6)		1.15 (0.93–1.42)
⩾28	2,352	127	5.4 (4.5–6.3)		1.00 (reference)
Smoking status†				<0.001	
Never-smoker	12,471	644	5.2 (4.8–5.6)		1.00 (reference)
Current smoker	5,911	675	11.4 (10.6–12.2)		1.27 (1.05–1.54)
Ex-smoker	1,863	349	18.7 (17.0–20.5)		1.72 (1.40–2.11)
Amount of smoking, pack-years				<0.001‡	
0–14	15,004	861	5.7 (5.4–6.1)		1.00 (reference)
15–29	2,547	298	11.7 (10.5–12.9)		1.30 (1.07–1.58)
30–44	1,590	259	16.3 (14.5–18.1)		1.78 (1.44–2.19)
⩾45	1,104	250	22.6 (20.2–25.1)		1.72 (1.39–2.14)
Occupational exposure to dusts/gases/fumes				0.001	
Never	16,101	1,274	7.9 (7.5–8.3)		1.00 (reference)
Ever	4,144	394	9.5 (8.6–10.4)		1.20 (1.04–1.39)
Ventilation in the kitchen				<0.001	
Poor	8,714	808	9.3 (8.7–9.9)		1.28 (1.14–1.43)
Good	11,531	860	7.5 (7.0–7.9)		1.00 (reference)
Indoor exposure to biomass for cooking or heating				<0.001	
Never	10,661	776	7.3 (6.8–7.8)		1.00 (reference)
Ever	9,584	892	9.3 (8.7–9.9)		1.35 (1.20–1.52)
Pulmonary problems in childhood				0.002	
Never	15,412	1,218	7.9 (7.5–8.3)		1.00 (reference)
Ever	4,833	450	9.3 (8.5–10.1)		1.21 (1.05–1.40)
Family history of pulmonary diseases				<0.001	
Never	15,764	1,128	7.2 (6.8–7.6)		1.00 (reference)
Ever	4,481	540	12.1 (11.1–13.0)		2.18 (1.93–2.45)

Definition of abbreviations: BMI = body mass index; CI = confidence interval; COPD = chronic obstructive pulmonary disease; OR = odds ratio.

* Post-bronchodilator $FEV_1/FVC < 70\%$ was defined as COPD according to GOLD (Global Initiative for Chronic Obstructive Lung Disease) diagnostic criteria.

† The COPD prevalence in smokers (including current smokers and ex-smokers) was 13.2%.

‡ *P* value for trend.

studies on the association between COPD and pulmonary problems in childhood, such as cohort studies, are needed for further evaluation and validation. The cause–effect relationship between BMI and COPD remains to be elucidated. Family history of respiratory diseases was also found to be associated with a higher prevalence of COPD in the present study, suggesting possible involvement of genetic or family-related environmental factors in the development of this disease. The prevalence of COPD in China varied with geographic area, gender, and age, which is consistent with other studies (18, 24). The association between indoor air pollution and COPD is a worldwide concern, especially in developing countries (36–38). The present study also showed a higher prevalence of COPD in subjects with exposure to biomass or with poor ventilation in the kitchen. In addition, there was a higher adjusted OR for COPD in rural areas than urban areas, which may be associated with more biomass exposure, lower socioeconomic status, lower education degree, lower health care standard, and poorer quality of cigarettes consumed in the countryside (data not shown). More than one-third of patients with COPD were asymptomatic in this population study, and nearly two thirds had never been diagnosed before this survey. Similarly, in a Japanese study, only 9.4% of cases with airflow limitation reported a previous diagnosis of COPD (16). This suggests that diagnosis of COPD based on symptoms may not be adequate.

The fact that an even smaller percentage (6.5%) of diagnosed subjects had ever been examined with spirometry further indicates the need for the use of spirometry to be strongly encouraged in community clinics. On the other hand, although COPD diagnostic criteria of GOLD are widely accepted, they may yield

TABLE 5. PREVALENCE OF CHRONIC OBSTRUCTIVE PULMONARY DISEASE* ACCORDING TO GLOBAL INITIATIVE FOR CHRONIC OBSTRUCTIVE LUNG DISEASE SEVERITY

	Prevalence†		
GOLD Stage	Men	Women	All
Stage 0‡	20.0 (19.2–20.9)	13.2 (12.6–13.8)	16.1 (15.6–16.6)
Stage I	2.8 (2.5–3.2)	1.4 (1.1–1.6)	2.0 (1.8–2.2)
Stage II	5.8 (5.3–6.3)	2.3 (2.0–2.5)	3.8 (3.5–4.1)
Stage III	2.6 (2.2–2.9)	1.0 (0.8–1.2)	1.7 (1.5–1.8)
Stage IV	0.8 (0.6–0.9)	0.2 (0.1–0.3)	0.4 (0.4–0.5)
Unknown stage§	0.4 (0.3–0.6)	0.3 (0.2–0.4)	0.3 (0.3–0.4)

Definition of abbreviation: GOLD = Global Initiative for Chronic Obstructive Lung Disease

* Post-bronchodilator $FEV_1/FVC < 70\%$ was defined as chronic obstructive pulmonary disease according to GOLD diagnostic criteria.

† Data are shown as prevalence in percentage with 95% confidence intervals in parentheses.

‡ Stage 0 was defined as having chronic cough or phlegm with an FEV_1/FVC of ≥ 0.70.

§ Patient completed prebronchodilator spirometry, chest radiographs, and electrocardiogram and was confirmed as having chronic obstructive pulmonary disease but did not complete at least two acceptable post-bronchodilator spirometries.

more false-negative results among younger adults and more false-positive results among older adults (39, 40), which makes it necessary for asymptomatic patients be further investigated in a cohort study.

The present study showed higher prevalence of stage III (1.7%) and IV (0.4%) and lower prevalence of stage I (2.0%) and stage II (3.8%) of COPD in China than that in some of the Latin American cities (18). This could be attributed to the fact that due to lower health care standard and general lack of medical knowledge among people, most of the patients with COPD in China did not visit a doctor until they develop significant symptoms and exacerbations, especially in rural areas where major health care disparities exist. Hence, most diseases would have developed to a more advanced and severe stage by the time the diagnosis is made. The lower proportion of younger subjects in the responders may be another explanation. In addition, subjects with mild obstruction but short expiration times may not meet the FEV/FVC threshold, resulting in a "low" COPD prevalence and a "high" restrictive prevalence. However, in the present study, spirometry tests were performed according to ATS recommendation by well trained spirometric physicians. Subjects were encouraged to inhale as much air as they could and to continue to exhale the air at the end of the maneuver. FEV_1 of more than 6 seconds and/or the 15 volume–time curve reached a plateau, which meant there was no change in volume ($\leq$0.03 L) for at least 1 second. Thus, in our study, good quality control in spirometry was assured, and "high" prevalence of modified restrictive disorder was not observed in some of the areas with "low" prevalence of modified-GOLD COPD (*see* Table 3 and Table E2).

One of the limitations in the present study was that data on smoking status were not obtained from all of the nonresponse population due to contact failure, and there were differences in age, sex, and urban/rural between responders and nonresponders. However, because the pattern of age and sex distribution in responders was similar to that of the whole population, the total response rate was relatively high. Moreover, contact failure, the major cause of nonresponse in this study, seems to be a random cause of nonresponse, so some possible selection bias should thus be negligible.

Second, the predicted normative values of FEV_1 were derived from ECCS equations and adjusted with conversion factors recommended by Zheng and Zhong (10) to minimize variations from ethnic differences. The adjusted conversion factors were obtained by comparing ECCS equations with Chinese equations, which were summarized from a nationwide normal lung function study (41), with 26 participating hospitals and institutions throughout the country and an enrollment of 4,773 Chinese healthy individuals ranging from 15 to 78 years of age. Although other prediction equations are available, larger ethnic differences can arise from these equations (10). Nevertheless, because there is no predicted value of FEV_1 for adults over 78 years of age, the COPD diagnosis could not be further identified by the criteria of below fifth percentile of the predicted value, and the severity of COPD would also be affected if there is a systemic reason (e.g., diet or air pollution) responsible for poor lung function. However, according to diagnostic criteria of GOLD, the investigation on COPD prevalence must to be consistent with the study methods of BOLD and comparable with the results reported by BOLD study.

Third, the possibility of misclassifying some subjects with asthma and other diseases as patients with COPD could not be eliminated. In addition, a recall bias was inevitable, like in all cross-sectional studies. Due to the impracticality of testing with the bronchodilator for all subjects in this large-scale study, only those with airflow limitation received a dose of Ventolin. This would bias toward a lower prevalence because some people

TABLE 6. FREQUENCIES OF RESPIRATORY SYMPTOMS AND PREVIOUS DIAGNOSIS OF CHRONIC RESPIRATORY DISEASES IN PATIENTS WITH CHRONIC OBSTRUCTIVE PULMONARY DISEASE

Symptoms and Previous Diagnosis	Frequency in Patients with COPD (%) (n = 1,668)	Frequency in GOLD Staging* (%)				
		Stage I (n = 401)	Stage II (n = 770)	Stage III (n = 337)	Stage IV (n = 91)	P_{trend}
Cough	44.0	31.7	40.9	62.0	57.1	<0.001
Sputum	39.5	24.9	39.5	54.9	50.5	<0.001
Wheezing	29.3	15.2	25.6	47.8	53.8	<0.001
Dyspnea†	48.6	32.6	46.1	65.8	75.3	<0.001
One of above	64.7	47.4	64.7	79.5	84.6	<0.001
Chronic cough with phlegm‡	30.0	17.0	28.6	45.7	40.7	<0.001
Lifetime diagnosis of COPD§	35.1	18.2	30.4	57.9	73.6	<0.001
Spirometry test	6.5	4.7	6.1	9.2	9.9	<0.001

Definition of abbreviations: COPD = chronic obstructive pulmonary disease; GOLD = Global Initiative for Chronic Obstructive Lung Disease.

* Total valid number of GOLD stages was 1,599.

† The number of reports of breathlessness included in the analysis was 1,610. Some subjects were excluded because of disability of walking due to other diseases such as stroke, with 389 of stage I, 740 of stage II, 325 of stage III, and 89 of stage IV.

‡ Cough with phlegm for at least 3 months per year in the previous 2 years.

§ Including COPD, bronchitis, emphysema, and asthma.

reportedly move from unobstructed to obstructed after a bronchodilator dose (because their FVC improves more significantly than FEV_1 or due to some type of paradoxical response), as reported by Johannessen and colleagues (42). To evaluate the bias and to compare our study with other studies, the prevalence of COPD according to "modified GOLD criteria" (11.5%; *see* Table E2), the modified restrictive disorder (8.5%; *see* Table E3), and the changed lung function from prebronchodilator to post-bronchodilator for subjects with a low ratio of prebronchodilator FEV_1/FVC (<70%) (*see* Figure E2S) are shown in the online supplement. As shown in Figure E2, for subjects with a low ratio of prebronchodilator FEV_1/FVC (<70%), FEV_1 and FVC increased by a mean of 50 ml and 40 ml, respectively, after a post-bronchodilator spirometric testing, in alignment with Johannessen and colleagues' findings (42). Also consistent with the findings (3.1%) of Johannessen and colleages (42) was our finding that 3.3% of population had a low ratio of FEV_1/FVC (FEV_1/FVC <70%) before bronchodilation and a normal ratio (FEV_1/FVC $\geq$ 70%) after bronchodilation (*see* Table 3 and Table E2) in the present study.

In conclusion, this nationwide, population-based and spirometry-based, cross-sectional survey showed that the prevalence of COPD in China is 8.2% in people 40 years of age or older according to GOLD criteria and 11.5% according to modified GOLD criteria, which is higher than previously expected. Our results highlight COPD as a major public health problem in China and call for more research to be directed toward preventive measures and efforts.

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References

1. Pauwels RA, Buist AS, Calverley PM, Jenkins CR, Hurd SS, on behalf of the GOLD Scientific Committee. Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease. NHLBI/WHO Global Initiative for Chronic Obstructive Lung Disease (GOLD) workshop summary [Internet]. 2006 [accessed 2005 Jul 16]. Available from: http://www.goldcopd.org.
2. Sullivan SD, Ramsey SD, Lee TA. The economic burden of COPD. *Chest* 2000;117:5S–9S.
3. Lopez AD, Murray CC. The global burden of disease, 1990–2020. *Nat Med* 1998;4:1241–1243.
4. Halbert RJ, Isonaka S, George D, Iqbal A. Interpreting COPD prevalence estimates: what is the true burden of disease? *Chest* 2003; 123:1684–1692.
5. Cheng X, Li J, Zhang Z. Analysis of basic data of the study on prevention and treatment of COPD and chronic cor pulmonale. *Zhonghua Jie He He Hu Xi Za Zhi (Chin)* 1998;21:749–752.
6. Xu F, Yin X, Zhang M, Shen H, Lu L, Xu Y. Prevalence of physician-diagnosed COPD and its association with smoking among urban and rural residents in regional mainland China. *Chest* 2005;128:2818–2823.
7. Ran PX, Liu SM, Zhou YM, Zheng JP, Lu JC, Wang C, *et al.* A study of potential risk factors for COPD in China [abstract]. *Respirology* 2006;11(Suppl 5):A120.
8. American Thoracic Society. American Thoracic Society statements: standardization of spirometry: 1994 Update. *Am J Respir Crit Care Med* 1995;152:1107–1136.
9. Enright PL, Studnicka M, Zielinski J. Spirometry to detect and manage chronic obstructive pulmonary disease and asthma in the primary care setting. In: Wouters EF, Gosselink R, Stam H, editors. Lung function testing. *Eur Respir Mon* 2005;31:1–14. Available from: http://www.viasyshealthcare.com/prod_serv/downloads/ra_ch1.pdf
10. Zheng J, Zhong N. Normative values for pulmonary function testing in Chinese adults. *Chin Med J (Engl)* 2002;115:50–54.
11. Buist AS, Vollmer WM, Sullivan SD, Weiss KB, Lee TA, Menezes AM, Crapo RO, Jensen RL, Burney PG. The Burden of Obstructive Lung Disease Initiative (BOLD): rationale and design. *COPD* 2005;2:277–283.
12. Bestall JC, Paul EA, Garrod R, Garnham R, Jones PW, Wedzicha JA. Usefulness of the Medical Research Council (MRC) dyspnoea scale as a measure of disability in patients with chronic obstructive pulmonary disease. *Thorax* 1999;54:581–586.
13. Ahmad OB, Boschi-Pinto C, Lopez AD, Murray CJ, Lozano R, Inoue M. Age standardization of rates: a new WHO standardization. Available from: http://www.emro.who.int/ncd/publications/WHO_pop_standard.pdf
14. U.S. Census Bureau. We the people: women and men in the united states-census 2000 special reports. Available from: http://www.census.gov/prod/2005pubs/censr-20.pdf
15. Regional COPD working group. COPD prevalence in 12 Asia-Pacific countries and regions: projections based on the COPD prevalence estimation model. *Respirology* 2003;8:192–198.
16. Fukuchi Y, Nishimura M, Ichinose M, Adachi M, Nagai A, Kuriyama T, Takahashi K, Nishimura K, Ishioka S, Aizawa H, *et al.* COPD in Japan: the Nippon COPD epidemiology study. *Respirology* 2004;9:458–465.
17. Plywaczewski R, Bednarek M, Jonczak L, Zielinski J. Prevalence of COPD in Warsaw population. *Pneumonol Alergol Pol* 2003;71:329–335.
18. Menezes AM, Perez-Padilla R, Jardim JR, Muino A, Lopez MV, Valdivia G, Montes de Oca M, Talamo C, Hallal PC, Victoria CG. Chronic obstructive pulmonary disease in five Latin American cities (the PLATINO study): a prevalence study. *Lancet* 2005;366:1875–1881.
19. Schirnhofer L, Lamprecht B, Vollmer WM, Allison MJ, Studnicka M, Jensen RL, Buist AS. COPD prevalence in Salzburg, Austria: results from the Burden of Obstructive Lung Disease (BOLD) study. *Chest* 2007;131:29–36.
20. Kim DS, Kim YS, Jung KS, Chang JH, Lim CM, Lee JH, Uh ST, Shim JJ, Lew WJ; Korean Academy of Tuberculosis and Respiratory Diseases. Prevalence of chronic obstructive pulmonary disease in Korea: a population-based spirometry survey. *Am J Respir Crit Care Med* 2005;172:842–847.
21. Jyrki-Tapani K, Sovijarvi A, Lundback B. Chronic obstructive pulmonary disease in Finland: prevalence and risk factors. *COPD* 2005;2: 331–339.
22. Celli BR, Halbert RJ, Isonaka S, Schau B. Population impact of different definitions of airway obstruction. *Eur Respir J* 2003;22:268–273.
23. Tzanakis N, Anagnostopoulou U, Filaditaki V, Christaki P, Siafakas N. Prevalence of COPD in Greece. *Chest* 2004;125:892–900.
24. Pena VS, Miravitlles M, Gabriel R, Jimenez-Ruiz CA, Villasante C, Masa JF, Viejo JL, Fernandez-Fau L. Geographic variations in prevalence and underdiagnosis of COPD: results of the IBERPOC multicentre epidemiological study. *Chest* 2000;118:981–989.
25. Shahab L, Jarvis MJ, Britton J, West R. COPD prevalence, diagnosis and relation to tobacco dependence of chronic obstructive pulmonary disease in a nationally representative population sample. *Thorax* 2006;61:1043–1047.
26. Murtagh E, Heaney L, Gingles J, Shepherd R, Kee F, Patterson C, MacMahon J. Prevalence of obstructive lung disease in a general population sample: the NICECOPD study. *Eur J Epidemiol* 2005;20:443–453.
27. Jindal SK, Aggarwal AN, Chaudhry K, Chhabra SK, D'Souza GA, Gupta D, Katiyar SK, Kumar R, Shah B, Vijayan VK; Asthma Epidemiology Study Group. A multicentric study on epidemiology of chronic obstructive pulmonary disease and its relationship with tobacco smoking and environmental tobacco smoke exposure. *Indian J Chest Dis Allied Sci* 2006;48:23–29.
28. Viegi G, Pedreschi M, Pistelli F, Di Pede F, Baldacci S, Carrozzi L, Giuntini C. Prevalence of airways obstruction in a general population: European Respiratory Society vs American Thoracic Society definition. *Chest* 2000;117:339S–345S.
29. Lindberg A, Bjerg-Backlund A, Ronmark E, Larsson LG, Lundback B. Prevalence and underdiagnosis of COPD by disease severity and the attributable fraction of smoking: report from the Obstructive Lung Disease in Northern Sweden Studies. *Respir Med* 2006;100:264–272.
30. Halbert RJ, Natoli JL, Gano A, Badamgarav E, Buist AS, Mannino DM. Global burden of COPD: systematic review and meta-analysis. *Eur Respir J* 2006;28:523–532.

31. Centers for Disease Control and Prevention. Cigarette smoking attributable morbidity: United States, 2000. *MMWR Morb Mortal Wkly Rep* 2003;52:842–844.
32. Ezzati M, Lopez AD. Estimates of global mortality attributable to smoking in 2000. *Lancet* 2003;362:847–852.
33. Attfield MD. Longitudinal decline in FEV1 in United States coalminers. *Thorax* 1985;40:132–137.
34. Hogg JC. Childhood viral infection and the pathogenesis of asthma and chronic obstructive lung disease. *Am J Respir Crit Care Med* 1999;160: 26S–28S.
35. Prescott E, Vestbo J. Socioeconomic status and chronic obstructive pulmonary disease. *Thorax* 1999;54:737–741.
36. Ezzati M, Kammen DM. Indoor air pollution from biomass combustion and acute respiratory infections in Kenya: an exposure-response study. *Lancet* 2001;358:619–624.
37. Ekici A, Ekici M, Kurtipek E, Akin H, Arslan M, Kara T, Apazdin Z, Demir S. Obstructive airway diseases in women exposed to biomass smoke. *Environ Res* 2005;99:93–98.
38. Shengming L, Yumin Z, Xiaoping W, Dali W, Jiachun L, Pixin R. Biomass fuels are the probable risk factor of chronic obstructive pulmonary disease in rural south China. *Thorax* [Epub ahead of print 2007 May 4]
39. Wilson D, Adams R, Appleton S, Ruffin R. Difficulties identifying and targeting COPD and population-attributable risk of smoking for COPD: a population study. *Chest* 2005;128:2035–2042.
40. Lundback B, Lindberg A, Lindstrom M, Rönmark E, Jonsson AC, Jönsson E, Larsson LG, Andersson S, Sandström T, Larsson K. Not 15 but 50% of smokers develop COPD? Report from the Obstructive Lung Disease in Northern Sweden Studies. *Respir Med* 2003;97:115–122.
41. Mu KJ, Liu SW. Nationwide normal values of lung function. Beijing: PUMC and Beijing Medical University; 1990.
42. Johannessen A, Omenaas ER, Bakke PS, Gulsvik A. Implications of reversibility testing on prevalence and risk factors for chronic obstructive pulmonary disease: a community study. *Thorax* 2005;60:842–847.