# Prevalence, risk factors, and management of asthma in China: a national cross-sectional study

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## Summary

**Background** Asthma is a common chronic airway disease worldwide. Despite its large population size, China has had no comprehensive study of the national prevalence, risk factors, and management of asthma. We therefore aimed to estimate the national prevalence of asthma in a representative sample of the Chinese population.

**Methods** A representative sample of 57 779 adults aged 20 years or older was recruited for the national cross-sectional China Pulmonary Health (CPH) study using a multi-stage stratified sampling method with parameters derived from the 2010 census. Ten Chinese provinces, representative of all socioeconomic settings, from six geographical regions were selected, and all assessments were done in local health centres. Exclusion criteria were temporary residence, inability to take a spirometry test, hospital treatment of cardiovascular conditions or tuberculosis, and pregnancy and breastfeeding. Asthma was determined on the basis of a self-reported history of diagnosis by a physician or by wheezing symptoms in the preceding 12 months. All participants were assessed with a standard asthma questionnaire and were classed as having or not having airflow limitation through pulmonary function tests before and after the use of a bronchodilator (400 µg of salbutamol). Risk factors for asthma were examined by multivariable-adjusted analyses done in all participants for whom data on the variables of interest were available. Disease management was assessed by the self-reported history of physician diagnosis, treatments, and hospital visits in people with asthma.

**Findings** Between June 22, 2012, and May 25, 2015, 57 779 participants were recruited into the CPH study. 50 991 (21 446 men and 29 545 women) completed the questionnaire survey and had reliable post-bronchodilator pulmonary function test results and were thus included in the final analysis. The overall prevalence of asthma in our sample was 4·2% (95% CI 3·1–5·6), representing 45·7 million Chinese adults. The prevalence of asthma with airflow limitation was 1·1% (0·9–1·4), representing 13·1 million adults. Cigarette smoking (odds ratio [OR] 1·89, 95% CI 1·26–2·84; p=0·004), allergic rhinitis (3·06, 2·26–4·15; p<0·0001), childhood pneumonia or bronchitis (2·43, 1·44–4·10; p=0·002), parental history of respiratory disease (1·44, 1·02–2·04; p=0·040), and low education attainment (p=0·045) were associated with prevalent asthma. In 2032 people with asthma, only 28·8% (95% CI 19·7–40·0) reported ever being diagnosed by a physician, 23·4% (13·9–36·6) had a previous pulmonary function test, and 5·6% (3·1–9·9) had been treated with inhaled corticosteroids. Furthermore, 15·5% (11·4–20·8) people with asthma reported at least one emergency room visit and 7·2% (4·9–10·5) at least one hospital admission due to exacerbation of respiratory symptoms within the preceding year.

**Interpretation** Asthma is prevalent but largely undiagnosed and undertreated in China. It is crucial to increase the awareness of asthma and disseminate standardised treatment in clinical settings to reduce the disease burden.

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See Comment page 364

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## Introduction

Asthma is a common chronic airway disease worldwide, affecting 1–18% of the populations of different countries.[1] In general, the prevalence of asthma is higher in industrialised countries than in low-income and middle-income countries.[1–4] Several studies have shown that prevalence of self-reported or physician-diagnosed asthma in adults is low, ranging from 0·5% to 2·8% in various communities in China.[5–8] These studies were based on small samples restricted to certain regions or occupations, which are not representative of the general Chinese population.

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## Research in context

### Evidence before this study

We searched PubMed and the China National Knowledge Infrastructure database for articles published up to Dec 31, 2018, using the terms "asthma", "asthma and chronic obstructive pulmonary disease overlap", "asthma, airflow limitation", "asthma, chronic obstructive", "prevalence", "epidemiology", and "China". We screened papers by reviewing abstracts to identify full-text reports that were relevant to the study aims and identified two large surveys of asthma with inconsistent results. One report showed that the prevalence of physician-diagnosed asthma in China was 1·24% based on 164 215 participants aged 14 years or older from eight provinces and municipalities done during 2010–12. Another study reported an asthma prevalence of 5·8% in adolescents and adults aged 16–65 years on the basis of asthma-like symptoms or previous physician diagnosis in a phone-interview study with 47 216 participants from 18 major Chinese cities done during 2011. Additionally, the prevalence of asthma with airflow limitation has not been reported for the Chinese population. These studies show that reliable and accurate information on the prevalence of asthma in Chinese adults is urgently needed.

### Added value of this study

We report what is, to our knowledge, the largest and most comprehensive asthma survey to date from a nationally representative sample of 50 991 Chinese adults aged 20 years or older, using the European Community Respiratory Health Survey asthma questionnaire, followed by pulmonary function tests before or after the use of a bronchodilator. Our results show that the overall prevalence of asthma was 4·2%, which represents 45·7 million individuals, 13·1 million of whom had airflow limitation, accounting for 1·1% of the population. Additionally, asthma was largely underdiagnosed and undertreated in China. Cigarette smoking, biomass use, exposure to high concentrations of particulate matter, presence of mould in the home, and abnormal weight were also identified as major preventable risk factors.

### Implications of all the available evidence

Our study shows that asthma is a major public health challenge in China. Our findings call for a national programme to improve asthma prevention and management. Importantly, increasing the awareness of asthma and disseminating standardised treatment are important public health priorities to reduce the burden of asthma.

Furthermore, the rapid industrialisation and related changes in environment and lifestyle during the past three decades might have led to an increase in asthma in China. Jiangtao Lin and colleagues[9] reported a physician-diagnosed asthma prevalence of 1·2% in individuals aged 14 years or older from eight provinces and municipalities. Xiangdong Wang and colleagues[10] reported this prevalence to be 5·8% in adults aged 16–65 years, on the basis of asthma-like symptoms or previous diagnosis from a physician in a phone interview study in 18 major cities in China.[10] The differences in sampling, data collection, and diagnosis of asthma might contribute to this inconsistency.

Furthermore, the prevalence of asthma with airflow limitation, a progressive form of asthma, has not been reported in the Chinese population. Asthma with airflow limitation has been associated with a decreased quality of life, increased risk for future exacerbation, and increased needs for health-care resources.[1,11] It has been suggested that asthma with airflow limitation might be more common in low-income and middle-income countries, as a consequence of the higher prevalence of known risk factors and poorer management of asthma than in high-income countries.[1,11]

In order to provide important information needed for the development of national policies and programmes to reduce the burden of asthma in China, we did the China Pulmonary Health (CPH) study[12] in a large, nationally representative sample of Chinese adult men and women aged 20 years or older to estimate the prevalence of asthma, with and without airflow limitation. Additionally, we studied risk factors for prevalent asthma of any type and documented the current management of asthma in Chinese adults.

## Methods

### Study design and participants

CPH was a national cross-sectional study that enrolled a nationally representative sample of 57 779 Chinese adults aged 20 years or older. We used a multistage stratified cluster-sampling procedure, which considered geographical region, degree of urbanisation, economic development status, and the sex and age distribution, derived from the 2010 China census data.[13] Details of the design and sampling method of the CPH study have been described previously.[12] Briefly, in Stage 1, we selected ten provinces, autonomous regions, and municipalities (only regions below 1500 m altitude were included), which represented the socioeconomic statuses and lifestyles of six major geographical regions in China (appendix). We randomly selected a large city (>1 million people), a midsize city (500 000 to 1 million people), an economically developed county, and an underdeveloped county (based on being above or below the median of provincial gross domestic product) from each province or autonomous region in Stage 2. We randomly selected two urban districts from every city and two rural townships from every county in Stage 3. In stage 4, we randomly selected two urban residential communities from the urban districts or rural village communities from the rural townships (both types of communities of about 1000–2000 households). Finally, we randomly selected individuals aged 20 years or older from the selected communities, stratified by sex and age distribution based on the 2010 China census data. We selected only one participant from every household, without replacement. Temporary residents (living in their current residence for less than 1 year), those who were physically incapable of taking a spirometry test, those admitted to hospital for any cardiac condition in the preceding 3 months, those with treated tuberculosis, and women who were pregnant or breastfeeding were excluded. 160 study sites (80 urban and 80 rural communities) participated in the study. The study protocol was approved by the ethics review committees of the Capital Medical University (Beijing, China) and all other participating institutes. Written informed consent was obtained from all participants.

## Procedures

We defined asthma on the basis of a self-reported history of asthma diagnosis by a physician or by wheeze symptoms in the preceding 12 months, using an asthma questionnaire from the European Community Respiratory Health Survey (ECRHS).[14] This questionnaire has been widely implemented in large-scale epidemiology studies, including the Global Burden of Disease study[2] and the World Health Survey,[4] and has been well validated by several regional asthma surveys in China,[4,7,10] together with our own in-house study (appendix). Additionally, wheezing has been shown to be specifically linked to asthma from many descriptors particular to China by an early clinical investigation[15] and its assessment therefore contributes to the estimation of asthma prevalence.

Trained and certified technicians at the recruitment sites tested the pulmonary function of all participants with a MasterScreen Pneumo PC spirometer (CareFusion; Yorba Linda, CA, USA), before and after bronchodilator inhalation (400 μg salbutamol), according to a standard protocol.[16] Quality-control checks for the measurement results based on criteria from the American Thoracic Society and European Respiratory Society criteria[16] were done by an expert panel of physicians and senior technicians on all test reports in local health centres and on 20·3% of randomly sampled reports (or 11 156 of 54 957 participants who received the questionnaire and the post-bronchodolator test) in the leading centre.

We defined airflow limitation as a ratio of post-bronchodilator forced expiratory volume in 1 s ($FEV_1$) and forced vital capacity (FVC) of less than 0·70.[17] In a sensitivity analysis aimed at testing the validity of our definition of airflow limitation, we also used lower limits of normal (LLN) with Chinese reference values to define airflow limitation.[18] Positive bronchodilator reversibility was defined as an increase in $FEV_1$ of more than 12% and more than 200 mL from baseline, 20 min after bronchodilation with 400 μg salbutamol.[1]

Data on demographic characteristics, medical history, parental history of respiratory disease, smoking status, biomass use for cooking or heating, presence of mould in the home, body-mass index (BMI), medical treatments, health status, and age of onset of wheezing symptoms (if present) were collected by trained interviewers at local community health centres.[12] Duration of wheezing was calculated as the difference between current age and the age of onset of wheezing symtoms. Definitions of ever-smoker, passive smoking, biomass use, occupational exposure, history of childhood pneumonia or bronchitis, history of chronic bronchitis, and exposure to ambient particulate matter with a diameter less than 2·5 μm ($PM_{2·5}$) had been previously described.[12] Additionally, we defined mould exposure by the frequency of visible mould spots at home, categorised as frequent (cumulative >3 months per year), sometimes (1–3 months per year), and rare (<1 month per year). Allergic rhinitis was identified according to the Allergic Rhinitis and Its Impact on Asthma questionnaire.[19] We measured the health status of all participants using the physical component summary (PCS) score and the mental component summary (MCS) score of the 12-item Short Form Health Survey (SF-12).[20] Data on blood cell counts of participants were also collected. Selection bias was addressed with multistage stratified cluster sampling, and technicians were trained to avoid information bias. Multivariable-adjusted logistic regression analysis was used to adjust for confounding factors.

## Statistical analysis

All calculations were weighted to represent the general adult population aged 20 years or older in China, according to the 2010 population census,[13] and were stratified by sampling clusters.[12] We calculated weights using data from the census and the study sampling scheme, and adjusted for oversampling for women, refused participation in the study, and other demographic differences between the sample and the total population. Age-standardised prevalence of asthma was calculated on the basis of the census population data. A technique appropriate for the complex survey design (the Taylor series linearisation method) was used to calculate SEs.[21] The absolute number of people with asthma was calculated on the basis of the 2015 Chinese population.[22] Our analyses used all participants for whom the variables of interest were available. We did not impute missing data.

We assessed the significance of differences by ANOVA or Student's *t* test for continuous variables and by the $\chi^2$ test for categorical variables. The trend of prevalence by covariables was tested by use of the Cochran-Armitage test. We examined the association between risk factors and asthma by multivariable logistic regression analyses. Non-linear associations were determined by restricted cubic spline regression analysis. All statistical analyses were done with SUDAAN 11.0 (Research Triangle Institute, NC, USA) and SAS 9.4 (SAS Institute, NC, USA).

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See **Online** for appendix

| | No asthma | Asthma | | |
|---|---|---|---|---|
| | | Overall asthma | Asthma without airflow limitation | Asthma with airflow limitation |
| Participants | 48 959 (95·9%) | 2032 (4·2%) | 1362 (3·1%) | 670 (1·1%) |
| Male | 20 565 (50·3%) | 881 (56·5%) | 499 (54·1%) | 382 (63·3%) |
| Female | 28 394 (49·7%) | 1151 (43·5%) | 863 (45·9%) | 288 (36·7%) |
| Mean age (years) | 43·6 (0·8) | 49·2 (1·9) | 44·2 (1·2) | 63·1 (1·1) |
| Urban residents | 31 528 (52·0%) | 1351 (43%) | 958 (44·7%) | 393 (36·5%) |
| Rural residents | 17 431 (48·0%) | 681 (57·5%) | 404 (55·3%) | 277 (63·5%) |
| Education attainment | | | | |
| Primary school and lower | 12 074 (21·9%) | 681 (37·6%) | 364 (33·4%) | 317 (49·1%) |
| Middle and high school | 28 127 (52·6%) | 1043 (46·0%) | 741 (46·4%) | 302 (44·9%) |
| College and higher | 8758 (25·5%) | 308 (16·4%) | 257 (20·2%) | 51 (5·9%) |
| Cigarette smoking | | | | |
| Never-smoker | 35 123 (69·2%) | 1306 (55·4%) | 978 (58·6%) | 328 (46·5%) |
| Ever-smoker | 13 836 (30·8%) | 726 (44·6%) | 384 (41·4%) | 342 (53·5%) |
| Passive smoking at home | 16 897 (47·7%) | 703 (53·5%) | 532 (55·9%) | 171 (44·9%) |
| Biomass use | 12 946 (25·5%) | 682 (39·7%) | 401 (36·2%) | 281 (49·5%) |
| Annual mean $PM_{2.5}$ exposure (μg/m³) | 70·5 (2·8) | 76·1 (6·2) | 76·7 (7·4) | 74·6 (4·4) |
| Occupational exposure | 11 593 (24·5%) | 734 (34·4%) | 496 (33·4%) | 238 (36·9%) |
| Frequency of visible mould spots in the current residence | | | | |
| Rarely | 36 127 (69·3%) | 1344 (57·4%) | 891 (57·6%) | 453 (56·9%) |
| Sometimes | 10 102 (24·1%) | 483 (31·7%) | 337 (30·5%) | 146 (34·8%) |
| Often | 2253 (6·6%) | 182 (10·9%) | 122 (11·8%) | 60 (8·3%) |
| History of pneumonia or bronchitis during childhood | 2107 (4·8%) | 337 (12·9%) | 231 (13·6%) | 106 (11·2%) |
| Parental history of respiratory diseases | 7960 (16·3%) | 649 (27·7%) | 412 (26·0%) | 237 (32·2%) |
| Mean body-mass index (kg/m²) | 23·6 (0·2) | 24·3 (0·6) | 24·6 (0·9) | 23·5 (0·3) |
| Allergic rhinitis | 4729 (11·1%) | 563 (26·7%) | 419 (30·4%) | 144 (16·7%) |

Data are weighted and shown as number (%) or mean (SE). Overall asthma was defined as physician-diagnosed asthma or wheeze in the preceding 12 months. Airflow limitation was defined as post-bronchodilator $FEV_1$/FVC of <70%. Ever-smoker was defined as having smoked equal to or more than 100 cigarettes in the lifetime. Passive smoking at home was shown with never-smokers. Occupational exposure was defined as exposure to gas–smoke–chemical vapours–or fumes in work for more than 3 months in the lifetime. $PM_{2.5}$=particulate matter with a diameter less than 2·5 μm. $FEV_1$=forced expiratory volume in 1 s. FVC=forced vital capacity.

*Table 1:* **Demographics and risk factors by types of asthma in the general Chinese adult population**


## 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 author had full access to all the data in the study and had final responsibility for the decision to submit for publication.


## Results

Participants were recruited between June 22, 2012, and May 25, 2015. 57 779 adults were invited to participate in the survey; 2822 refused to participate in the survey and 3966 were excluded from the analysis because they had no information on asthma, did not complete the post-bronchodilator test, or had unreliable results from the post-bronchodilator test. Thus, the analysis for determining asthma included 50 991 individuals (21 446 men and 29 545 women) who completed the questionnaire survey and had reliable pulmonary function tests before and after using a bronchodilator (appendix). The distribution of our study population by general characteristics and risk factors is summarised in table 1. 2032 people with asthma were identified from the 50 991 participants and the distribution of people with asthma or airflow limitation (ie, spirometry-defined chronic obstructive pulmonary disease) in the general Chinese population is shown in the appendix. The overall prevalence of asthma was estimated to be 4·2% (95% CI 3·1–5·6) on the basis of these individuals, and the prevalence of asthma with airflow limitation was 1·1% (670 people with asthma with airflow limitation, 0·9–1·4; table 1). Asthma prevalence did not differ between men (4·6%, 95% CI 3·0–7·1) and women (3·7%, 3·0–4·5, p=0·18), or between rural (4·9%, 95% CI 3·1–7·7) and urban (3·6%, 3·0–4·4, p=0·27) areas. However, the prevalence of asthma increased with age, from 2·5% (95% CI 1·5–4·4) in individuals aged 20 to 39 years to 5·4% (4·3–6·8, p=0·001) in those aged 40 years or older (table 2). This increasing trend with age was also significant for asthma with airflow limitation, for which the prevalence was 1·9% (95% CI 1·6–2·4) in those aged 40 years or older. The prevalence of asthma with airflow limitation in individuals aged younger than 40 years was 0·1% (0·0–0·2). Because $FEV_1$/FVC is age-dependent, we did a sensitivity analysis of the complete participant population using age-specific LLN to define airflow limitation. We found that the overall prevalence of asthma with LLN-defined airflow limitation was 1·2% (95% CI 0·9–1·5%). However, the prevalence of asthma with airflow limitation was slightly increased for adults younger than 50 years and slightly decreased for adults older than 60 years, compared with using fixed $FEV_1$/FVC ratio to define airflow limitation (appendix). The prevalence of asthma increased with age regardless of smoking status, despite asthma being more prevalent in ever-smokers than in never-smokers (appendix).

On the basis of the 2015 Chinese population, we estimated that the number of Chinese adults with asthma was 45·7 million (95% CI 27·7–78·0), including 25·7 million men (15·3–45·4) and 20·0 million women (12·4–32·6). We also estimated that 13·1 million Chinese adults had asthma with airflow limitation (8·2–22·3), including 8·3 million men (5·6–12·8) and 4·8 million women (2·7–9·5).

Allergic rhinitis and smoking are well known risk factors for asthma. The age-standardised prevalence of asthma was 10·2% (95% CI 8·4–12·4) in those with allergic rhinitis and 3·5% (2·6–4·7) in those without allergic rhinitis (p<0·0001; table 2). In ever-smokers, the age-standardised prevalence of asthma was 5·8% (3·8–8·7), compared with 3·5% (2·8–4·4) in never-smokers (p=0·032). Approximately 31·8% of ever-smoking people with asthma had airflow limitation, who represented a higher proportion than the 22·2% of

| | Overall asthma | | | Asthma without airflow limitation | | | Asthma with airflow limitation | | |
|---|---|---|---|---|---|---|---|---|---|
| | Men | Women | Total | Men | Women | Total | Men | Women | Total |
| **Age (years)** | | | | | | | | | |
| 20–29 | 1·9% (1·1–3·5) | 2·4% (1·4–4·1) | 2·2% (1·5–3·2) | 1·9% (1·1–3·5) | 2·4% (1·4–4·1) | 2·2% (1·5–3·2) | 0·0 | 0·0 | 0·0 |
| 30–39 | 2·9% (1·1–7·3) | 3·0% (1·5–6·0) | 2·9% (1·3–6·5) | 2·8% (1·1–7·1) | 2·8% (1·3–5·8) | 2·8% (1·2–6·3) | 0·0% (0·0–0·3) | 0·2% (0·1–0·5) | 0·1% (0·0–0·3) |
| 40–49 | 7·4% (3·4–15·3) | 3·0% (2·1–4·3) | 5·2% (3·1–8·7) | 6·6% (2·9–14·4) | 2·6% (1·8–3·9) | 4·7% (2·6–8·3) | 0·7% (0·3–1·6) | 0·4% (0·2–0·8) | 0·6% (0·4–0·8) |
| 50–59 | 4·1% (3·1–5·4) | 4·5% (3·1–6·6) | 4·3% (3·1–5·9) | 2·5% (2·0–3·1) | 3·5% (2·3–5·4) | 3·0% (2·2–4·1) | 1·6% (1·0–2·8) | 1·0% (0·6–1·6) | 1·3% (0·9–2·0) |
| 60–69 | 6·4% (5·4–7·6) | 5·6% (4·2–7·6) | 6·0% (5·1–7·2) | 2·1% (1·4–3·0) | 3·1% (1·8–5·3) | 2·6% (1·9–3·5) | 4·4% (3·6–5·3) | 2·6% (1·9–3·5) | 3·5% (2·9–4·2) |
| ≥70 | 8·5% (5·7–12·5) | 6·5% (3·0–13·3) | 7·4% (4·8–11·3) | 1·3% (0·6–2·8) | 3·0% (1·8–4·9) | 2·2% (1·4–3·5) | 7·2% (4·6–11·1) | 3·5% (1·3–9·3) | 5·3% (3·3–8·3) |
| p value for trend | 0·011 | 0·020 | 0·0054 | 0·034 | 0·47 | 0·78 | 0·0002 | 0·0056 | <0·0001 |
| **Urbanisation** | | | | | | | | | |
| Urban | 3·5% (2·7–4·4) | 3·8% (3·1–4·7) | 3·6% (3·0–4·4) | 2·2% (1·7–2·9) | 3·2% (2·5–4·1) | 2·7% (2·1–3·3) | 1·3% (1·0–1·6) | 0·7% (0·5–0·8) | 1·0% (0·8–1·2) |
| Rural | 6·2% (3·6–10·5) | 3·6% (2·2–5·7) | 4·9% (3·1–7·7) | 4·4% (2·1–9·0) | 2·5% (1·2–5·0) | 3·5% (1·8–6·7) | 1·8% (1·4–2·4) | 1·1% (0·6–2·0) | 1·4% (1·1–1·8) |
| p value for difference | 0·10 | 0·79 | 0·27 | 0·18 | 0·49 | 0·50 | 0·084 | 0·24 | 0·041 |
| **Education attainment** | | | | | | | | | |
| Primary school and lower | 7·1% (4·8–10·3) | 4·5% (2·8–7·1) | 5·6% (3·9–8·0) | 5·0% (3·1–8·0) | 3·4% (1·8–6·3) | 4·2% (2·6–6·6) | 2·1% (1·5–2·9) | 1·1% (0·7–1·7) | 1·5% (1·2–1·8) |
| Middle and high school | 4·5% (2·7–7·2) | 3·2% (2·4–4·2) | 3·9% (2·7–5·5) | 2·9% (1·4–6·0) | 2·3% (1·5–3·4) | 2·6% (1·5–4·5) | 1·6% (1·0–2·5) | 0·9% (0·5–1·5) | 1·3% (0·9–1·8) |
| College and higher | 3·0% (2·0–4·5) | 3·1% (2·1–4·5) | 3·0% (2·3–4·0) | 2·2% (1·4–3·3) | 2·5% (1·6–3·9) | 2·3% (1·7–3·1) | 0·8% (0·5–1·4) | 0·5% (0·3–1·1) | 0·7% (0·5–1·0) |
| p value for trend | 0·0081 | 0·33 | 0·037 | 0·024 | 0·53 | 0·085 | 0·0082 | 0·12 | 0·0023 |
| **Cigarette smoking** | | | | | | | | | |
| Never-smoker | 2·9% (2·0–4·4) | 3·8% (3·0–4·6) | 3·5% (2·8–4·4) | 2·1% (1·1–3·6) | 2·9% (2·1–3·9) | 2·6% (1·9–3·7) | 0·9% (0·6–1·4) | 0·9% (0·6–1·4) | 0·9% (0·6–1·2) |
| Ever-smoker | 5·9% (3·9–8·9) | 4·1% (2·8–6·0) | 5·8% (3·8–8·7) | 4·0% (2·2–6·9) | 2·3% (1·2–4·2) | 3·9% (2·2–6·8) | 2·0% (1·5–2·6) | 1·9% (1·1–3·2) | 1·9% (1·5–2·4) |
| p value for difference | 0·0066 | 0·65 | 0·032 | 0·041 | 0·43 | 0·15 | 0·0017 | 0·061 | 0·0030 |
| **Ever-smokers living in the home** | | | | | | | | | |
| None | 2·9% (1·7–5·0) | 3·1% (2·5–3·7) | 3·1% (2·3–4·1) | 2·1% (0·9–4·5) | 2·3% (1·7–3·0) | 2·2% (1·4–3·5) | 0·8% (0·5–1·3) | 0·8% (0·4–1·4) | 0·8% (0·5–1·3) |
| One | 3·1% (1·4–6·4) | 4·1% (3·3–5·2) | 3·9% (3·0–5·1) | 1·8% (0·8–3·9) | 3·2% (2·4–4·3) | 3·0% (2·2–4·0) | 1·3% (0·5–3·0) | 0·9% (0·6–1·5) | 1·0% (0·7–1·5) |
| Two or more | 3·8% (1·8–8·0) | 5·6% (3·2–9·7) | 5·4% (3·2–9·1) | 2·9% (1·3–6·4) | 4·6% (2·3–8·9) | 4·4% (2·3–8·2) | 0·9% (0·2–4·8) | 1·0% (0·6–1·8) | 1·1% (0·6–1·8) |
| p value for trend | 0·60 | 0·084 | 0·033 | 0·60 | 0·084 | 0·039 | 0·95 | 0·47 | 0·40 |
| **Biomass use** | | | | | | | | | |
| Yes | 7·1% (3·8–12·8) | 5·0% (3·1–7·9) | 6·0% (3·6–10·1) | 4·8% (2·0–10·9) | 3·7% (1·9–7·0) | 4·2% (2·0–8·6) | 2·3% (1·6–3·2) | 1·3% (0·9–2·0) | 1·8% (1·4–2·3) |
| No | 3·9% (2·8–5·4) | 3·2% (2·6–4·1) | 3·6% (3·0–4·3) | 2·7% (1·7–4·4) | 2·5% (1·9–3·4) | 2·6% (2·0–3·4) | 1·2% (0·9–1·5) | 0·7% (0·5–1·0) | 0·9% (0·8–1·1) |
| p value for difference | 0·13 | 0·17 | 0·10 | 0·26 | 0·35 | 0·25 | 0·014 | 0·0089 | 0·0020 |
| **Annual mean $PM_{2·5}$ exposure (μg/m³)** | | | | | | | | | |
| <50 | 8·2% (5·6–11·8) | 3·1% (2·0–4·7) | 6·3% (4·2–9·3) | 6·3% (4·0–10·0) | 2·5% (1·6–3·8) | 5·0% (3·1–7·8) | 1·9% (0·8–4·4) | 0·6% (0·3–1·1) | 1·3% (0·6–3·1) |
| 50–75 | 3·5% (2·6–4·6) | 2·8% (2·1–3·7) | 3·1% (2·5–3·9) | 1·8% (1·2–2·5) | 2·1% (1·4–3·2) | 2·0% (1·4–2·7) | 1·7% (1·2–2·4) | 0·7% (0·5–1·0) | 1·1% (0·9–1·4) |
| ≥75 | 6·0% (2·4–13·9) | 5·4% (4·2–6·9) | 5·6% (3·3–9·4) | 4·5% (1·6–12·2) | 4·1% (2·7–6·2) | 4·2% (2·1–8·3) | 1·5% (1·0–2·2) | 1·3% (0·6–2·8) | 1·4% (1·0–1·9) |
| p value for trend | 0·45 | 0·018 | 0·71 | 0·49 | 0·11 | 0·68 | 0·62 | 0·17 | 0·92 |

(Table 2 continues on next page)

| | Overall asthma | | | Asthma without airflow limitation | | | Asthma with airflow limitation | | |
|---|---|---|---|---|---|---|---|---|---|
| | Men | Women | Total | Men | Women | Total | Men | Women | Total |
| (Continued from previous page) | | | | | | | | | |
| **Occupational exposure** | | | | | | | | | |
| Yes | 5·1% (3·6–7·4) | 6·4% (4·2–9·5) | 5·7% (3·9–8·2) | 3·1% (1·7–5·4) | 5·2% (3·1–8·6) | 4·0% (2·3–6·7) | 2·1% (1·5–2·8) | 1·2% (0·8–1·8) | 1·7% (1·3–2·2) |
| No | 4·6% (3·0–6·8) | 3·1% (2·5–3·8) | 3·8% (3·0–4·8) | 3·2% (1·8–5·6) | 2·3% (1·7–3·1) | 2·7% (1·9–3·8) | 1·4% (1·0–2·0) | 0·8% (0·5–1·2) | 1·1% (0·9–1·3) |
| p value for difference | 0·53 | 0·017 | 0·043 | 0·89 | 0·033 | 0·15 | 0·096 | 0·049 | 0·011 |
| **Frequency of visible mould spots in the current residence** | | | | | | | | | |
| Rarely | 3·7% (2·2–6·2) | 3·4% (2·9–4·1) | 3·6% (2·7–4·8) | 2·6% (1·2–5·6) | 2·5% (1·9–3·2) | 2·5% (1·6–4·1) | 1·2% (0·9–1·5) | 0·9% (0·6–1·6) | 1·1% (0·8–1·4) |
| Sometimes | 7·2% (4·8–10·5) | 3·8% (2·7–5·4) | 5·5% (3·9–7·6) | 4·5% (2·3–8·8) | 3·1% (2·1–4·6) | 3·9% (2·4–6·2) | 2·6% (1·5–4·4) | 0·7% (0·5–1·0) | 1·6% (1·0–2·6) |
| Often | 7·5% (3·7–14·7) | 5·9% (3·4–10·0) | 6·6% (3·6–12·0) | 5·3% (2·2–11·9) | 5·0% (2·3–10·6) | 5·2% (2·3–11·1) | 2·3% (1·2–4·3) | 0·9% (0·3–2·3) | 1·5% (0·9–2·6) |
| p value for trend | 0·061 | 0·11 | 0·050 | 0·083 | 0·15 | 0·077 | 0·15 | 0·77 | 0·27 |
| **History of pneumonia or bronchitis during childhood** | | | | | | | | | |
| Yes | 9·9% (6·6–14·6) | 12·2% (9·1–16·2) | 10·9% (8·8–13·3) | 6·7% (4·3–10·2) | 8·8% (6·4–12·0) | 7·6% (6·0–9·5) | 3·2% (1·8–5·8) | 3·4% (2·0–5·7) | 3·3% (2·2–4·9) |
| No | 4·5% (3·1–6·6) | 3·3% (2·6–4·2) | 3·9% (2·9–5·3) | 3·0% (1·8–5·2) | 2·5% (1·8–3·5) | 2·8% (1·8–4·2) | 1·5% (1·2–1·9) | 0·8% (0·5–1·2) | 1·1% (0·9–1·4) |
| p value for difference | 0·0024 | 0·0001 | <0·0001 | 0·0013 | 0·0003 | <0·0001 | 0·067 | 0·0037 | 0·0024 |
| **Parental history of respiratory diseases** | | | | | | | | | |
| Yes | 6·9% (5·5–8·6) | 6·9% (5·3–8·9) | 6·9% (5·6–8·6) | 4·0% (3·0–5·3) | 5·3% (3·8–7·2) | 4·6% (3·5–6·2) | 2·9% (2·0–4·1) | 1·6% (1·2–2·3) | 2·3% (1·7–3·0) |
| No | 4·5% (2·9–6·8) | 3·1% (2·5–3·8) | 3·8% (2·8–5·0) | 3·1% (1·8–5·5) | 2·3% (1·8–3·1) | 2·8% (1·9–4·1) | 1·3% (1·0–1·7) | 0·7% (0·4–1·3) | 1·0% (0·8–1·3) |
| p value for difference | 0·010 | 0·0001 | <0·0001 | 0·21 | 0·0002 | <0·0001 | 0·0012 | 0·015 | 0·0006 |
| **Body-mass index (kg/m²)** | | | | | | | | | |
| <18·5 | 8·1% (4·4–14·4) | 4·5% (2·4–8·3) | 6·0% (3·9–9·0) | 5·7% (2·5–12·2) | 2·4% (1·0–5·6) | 3·7% (1·9–7·1) | 2·4% (1·7–3·5) | 2·2% (0·8–6·1) | 2·3% (1·5–3·6) |
| 18·5–24·9 | 3·9% (2·4–6·2) | 3·7% (2·8–4·7) | 3·8% (2·7–5·2) | 2·3% (1·1–4·6) | 2·7% (1·8–4·1) | 2·5% (1·5–4·2) | 1·6% (1·2–2·1) | 0·9% (0·6–1·5) | 1·3% (1·0–1·6) |
| ≥25 | 5·8% (3·6–9·3) | 3·5% (2·6–4·8) | 4·8% (3·4–6·8) | 4·4% (2·3–8·0) | 2·8% (2·0–4·0) | 3·8% (2·4–5·8) | 1·5% (1·0–2·2) | 0·7% (0·5–1·0) | 1·0% (0·8–1·3) |
| p value for trend | 0·46 | 0·49 | 0·49 | 0·64 | 0·63 | 0·94 | 0·083 | 0·18 | 0·0083 |
| **Allergic rhinitis** | | | | | | | | | |
| Yes | 9·2% (7·0–11·9) | 11·4% (9·1–14·2) | 10·2% (8·4–12·4) | 6·8% (4·8–9·7) | 9·5% (7·5–12·1) | 8·1% (6·4–10·2) | 2·4% (1·7 –3·2) | 1·9% (1·5–2·4) | 2·1% (1·7 –2·6) |
| No | 4·2% (2·7–6·3) | 2·8% (2·3–3·5) | 3·5% (2·6–4·7) | 2·7% (1·5–4·8) | 2·0% (1·4–2·8) | 2·3% (1·5–3·6) | 1·5% (1·1–2·0) | 0·8% (0·5–1·3) | 1·1% (0·9–1·4) |
| p value for difference | <0·0001 | <0·0001 | <0·0001 | <0·0001 | <0·0001 | <0·0001 | 0·065 | <0·0001 | 0·0006 |

Values are % (95% CI). p value for difference refers to the comparison of binary variables. Overall asthma was defined as physician-diagnosed asthma or wheeze in the preceding 12 months. Airflow limitation was defined as post-bronchodilator $FEV_1$/FVC of less than 70%. Ever-smoker was defined as having smoked equal to or more than 100 cigarettes in the lifetime. Passive smoking at home was shown with never-smokers. Occupational exposure was defined as exposure to gas–smoke–chemical vapours–or fumes in work for more than 3 months in the lifetime. p for trend refers to the linear trend of polytomous variables. All calculations of p values are weighted, accounting for the multistage cluster sampling design and based on the $\chi^2$ test. $PM_{2·5}$=particulate matter with a diameter less than 2·5 μm. $FEV_1$=forced expiratory volume in 1 s. FVC=forced vital capacity.

*Table 2:* **Age-specific and age-standardised prevalence of asthma in the general Chinese adult population**

| | Entire population | | | | | | Never-smokers | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Overall asthma | | Asthma without airflow limitation | | Asthma with airflow limitation | | Overall asthma | | Asthma without airflow limitation | | Asthma with airflow limitation | |
| | OR (95% CI) | p value | OR (95% CI) | p value | OR (95% CI) | p value | OR (95% CI) | p value | OR (95% CI) | p value | OR (95% CI) | p value |
| Male | 0·90 (0·63–1·29) | 0·55 | 0·78 (0·52–1·16) | 0·21 | 1·22 (0·71–2·11) | 0·45 | 0·86 (0·55–1·35) | 0·49 | 0·77 (0·47–1·27) | 0·28 | 1·05 (0·48–2·28) | 0·89 |
| Age (10 year increments) | 1·19 (0·96–1·47) | 0·10 | 0·93 (0·81–1·08) | 0·33 | 2·36 (1·86–3·00) | <0·0001 | 1·25 (0·97–1·61) | 0·081 | 1·01 (0·85–1·21) | 0·89 | 2·48 (1·88–3·28) | <0·0001 |
| Rural resident | 1·03 (0·67–1·57) | 0·89 | 0·97 (0·52–1·83) | 0·93 | 1·13 (0·55–2·31) | 0·73 | 0·74 (0·43–1·28) | 0·26 | 0·59 (0·41–0·85) | 0·0076 | 1·51 (0·42–5·37) | 0·51 |
| Ever-smoker | 1·89 (1·26–2·84) | 0·0042 | 1·86 (1·15–3·02) | 0·015 | 1·91 (1·29–2·84) | 0·0027 | .. | .. | .. | .. | .. | .. |
| Ever-smokers living in the home | .. | .. | .. | .. | .. | .. | .. | 0·21* | .. | 0·086* | .. | 0·74* |
| None | .. | .. | .. | .. | .. | .. | 1·00 | .. | 1·00 | .. | 1·00 | .. |
| One | .. | .. | .. | .. | .. | .. | 1·06 (0·63–1·80) | .. | 1·05 (0·56–1·98) | .. | 1·14 (0·74–1·77) | .. |
| Two or more | .. | .. | .. | .. | .. | .. | 1·24 (0·87–1·76) | .. | 1·35 (0·95–1·92) | .. | 0·85 (0·30–2·40) | .. |
| Biomass use | 1·22 (0·76–1·96) | 0·38 | 1·12 (0·65–1·94) | 0·67 | 1·61 (1·00–2·62) | 0·053 | 1·28 (1·05–1·57) | 0·019 | 1·23 (1·00–1·51) | 0·048 | 1·32 (0·80–2·19) | 0·27 |
| Annual mean $PM_{2·5}$ (μg/m³) | .. | 0·64* | .. | 0·59* | .. | 0·47* | .. | 0·049* | .. | 0·14* | .. | 0·18* |
| <50 | 1·00 | .. | 1·00 | .. | 1·00 | .. | 1·00 | .. | 1·00 | .. | 1·00 | .. |
| 50–75 | 0·49 (0·18–1·30) | .. | 0·38 (0·13–1·08) | .. | 1·57 (0·59–4·20) | .. | 1·37 (0·73–2·57) | .. | 1·34 (0·64–2·82) | .. | 1·57 (0·73–3·39) | .. |
| ≥75 | 0·82 (0·34–1·96) | .. | 0·77 (0·28–2·11) | .. | 1·44 (0·51–4·08) | .. | 1·89 (1·00–3·57) | .. | 1·87 (0·79–4·42) | .. | 2·15 (0·68–6·81) | .. |
| Education attainment | .. | 0·045* | .. | 0·023* | .. | 0·11* | .. | 0·21* | .. | 0·086* | .. | 0·37* |
| Primary school and lower | 1·00 | .. | 1·00 | .. | 1·00 | .. | 1·00 | .. | 1·00 | .. | 1·00 | .. |
| Middle and high school | 0·65 (0·38–1·12) | .. | 0·59 (0·27–1·26) | .. | 0·93 (0·46–1·88) | .. | 0·57 (0·34–0·95) | .. | 0·48 (0·29–0·81) | .. | 1·00 (0·52–1·93) | .. |
| College and higher | 0·46 (0·22–0·98) | .. | 0·39 (0·17–0·86) | .. | 0·54 (0·25–1·18) | .. | 0·57 (0·24–1·40) | .. | 0·47 (0·20–1·13) | .. | 0·70 (0·31–1·58) | .. |
| Occupational exposure | 0·97 (0·68–1·40) | 0·87 | 0·99 (0·64–1·52) | 0·95 | 1·08 (0·76–1·54) | 0·64 | 1·36 (0·85–2·20) | 0·19 | 1·58 (0·87–2·85) | 0·12 | 0·89 (0·59–1·35) | 0·57 |
| Frequency of visible mould spots in the current residence | .. | 0·34* | .. | 0·38* | .. | 1·00* | .. | 0·0062* | .. | 0·0003* | .. | 0·30* |
| Rarely | 1·00 | .. | 1·00 | .. | 1·00 | .. | 1·00 | .. | 1·00 | .. | 1·00 | .. |
| Sometimes | 1·47 (0·96–2·25) | .. | 1·46 (0·76–2·81) | .. | 1·43 (0·72–2·84) | .. | 1·29 (0·95–1·76) | .. | 1·38 (0·98–1·96) | .. | 1·02 (0·42–2·46) | .. |
| Often | 1·22 (0·79–1·88) | .. | 1·26 (0·74–2·15) | .. | 1·00 (0·51–1·94) | .. | 1·59 (1·16–2·19) | .. | 1·90 (1·41–2·58) | .. | 0·68 (0·31–1·46) | .. |
| History of pneumonia or bronchitis during childhood | 2·43 (1·44–4·10) | 0·0023 | 2·28 (1·25–4·18) | 0·010 | 2·82 (1·52–5·22) | 0·0024 | 2·54 (1·18–5·48) | 0·020 | 2·31 (1·00–5·35) | 0·050 | 3·88 (2·23–6·77) | <0·0001 |
| Parental history of respiratory diseases | 1·44 (1·02–2·04) | 0·040 | 1·32 (0·85–2·06) | 0·20 | 2·03 (1·31–3·15) | 0·0031 | 1·94 (1·35–2·80) | 0·0013 | 1·88 (1·45–2·43) | <0·0001 | 2·38 (0·96–5·90) | 0·059 |
| Body-mass index (kg/m²) | .. | 0·91* | .. | 0·45* | .. | 0·012* | .. | 0·22* | .. | 0·90* | .. | 0·085* |
| <18·5 | 1·40 (0·84–2·35) | .. | 1·18 (0·58–2·40) | .. | 1·58 (0·79–3·16) | .. | 1·57 (0·85–2·88) | .. | 1·35 (0·71–2·56) | .. | 2·13 (0·53–8·59) | .. |
| 18·5–24·9 | 1·00 | .. | 1·00 | .. | 1·00 | .. | 1·00 | .. | 1·00 | .. | 1·00 | .. |
| ≥25 | 1·35 (0·79–2·28) | .. | 1·67 (0·83–3·36) | .. | 0·85 (0·59–1·23) | .. | 1·11 (0·91–1·36) | .. | 1·30 (0·91–1·85) | .. | 0·76 (0·51–1·13) | .. |
| Allergic rhinitis | 3·06 (2·26–4·15) | <0·0001 | 3·53 (2·41–5·19) | <0·0001 | 1·70 (1·21–2·39) | 0·0041 | 3·29 (2·12–5·11) | <0·0001 | 3·49 (2·00–6·07) | 0·0002 | 2·64 (1·51–4·62) | 0·0019 |

Multivariable-adjusted analyses included all co-variables listed in the table. ORs of 1·00 indicate reference values. Overall asthma was defined as physician-diagnosed asthma or wheeze in the preceding 12 months. Airflow limitation was defined as post-bronchodilator $FEV_1$/FVC of <70%. Ever-smoker was defined as having smoked equal to or more than 100 cigarettes in the lifetime. Passive smoking at home was shown with never-smokers. Occupational exposure was defined as exposure to gas–smoke–chemical vapours–or fumes in work for more than 3 months in the lifetime. OR=odds ratio. $PM_{2·5}$=particulate matter with a diameter less than 2·5 μm. *p values for categorical variables with multiple levels were based on linear trend tests.

***Table 3:*** **Multiple adjusted odds ratios of asthma in the general Chinese adult population**

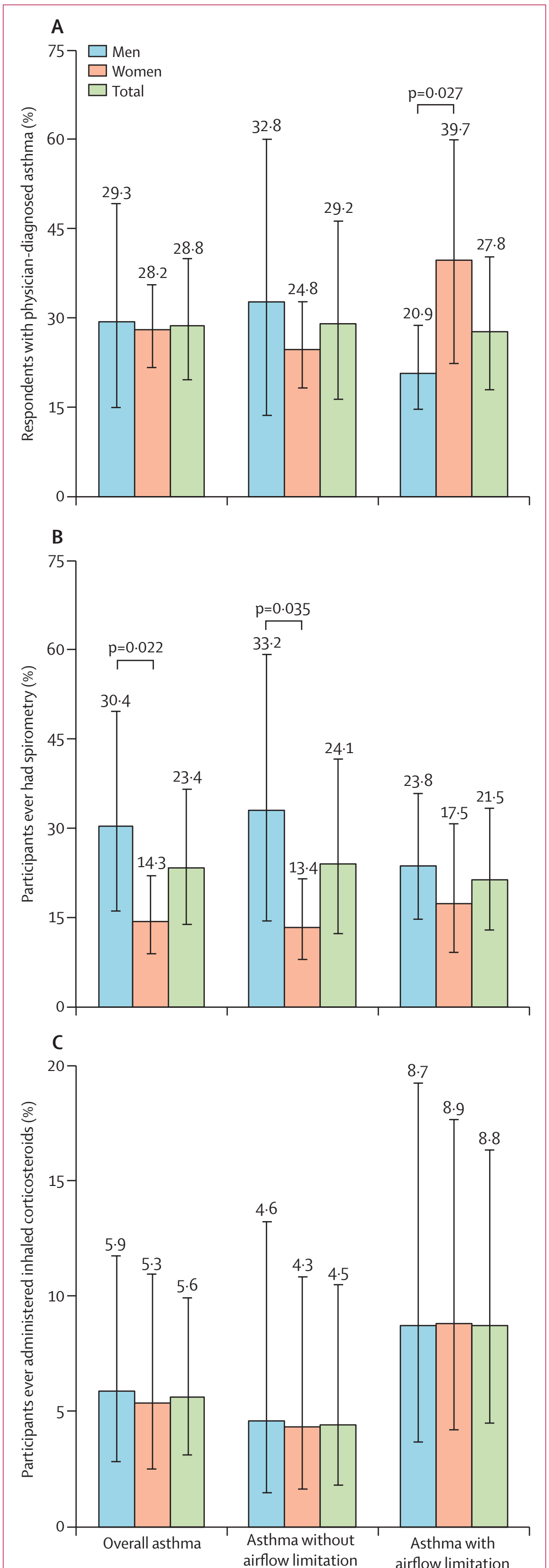


***Figure 1:* Proportion of asthma respondents with physician-diagnosed asthma, history of pulmonary function testing, or past treatment with inhaled corticosteroids**
(A) Proportion of people with a self-reported physician diagnosis of asthma by sex and by presence of airflow limitation. (B) Proportion of those with a history of pulmonary function test from people with asthma by sex and by presence of airflow limitation. (C) Proportion of those ever having taken corticosteroids from people with asthma by sex and by presence of airflow limitation. Bars represent proportion and 95% CI. p values are weighted, accounting for the multistage cluster sampling design of the study.

never-smoking people with asthma, although the difference was not significant (p=0·15; appendix).

In the multivariable-adjusted analyses, allergic rhinitis, cigarette smoking, history of pneumonia or bronchitis during childhood, and parental history of respiratory diseases were consistently associated with prevalent asthma and asthma with airflow limitation (table 3). Age was only associated with an increased risk of asthma with airflow limitation, whereas better education was associated with a reduced risk of asthma without airflow limitation (p=0·023 for those with a secondary or university education *vs* primary school graduates or people without formal education). When considering only never-smokers, biomass use, exposure to high concentrations of $PM_{2·5}$ (≥75 μg/m³), and frequent exposure to mould in the home were additionally associated with the prevalence of asthma (table 3). Finally, we found significant non-linear associations between BMI and asthma, without or with airflow limitation, through spline regression analyses in both the entire population and never-smokers (p<0·0001 and p=0·041 in the entire population, and p<0·0001 and p<0·0001 in never-smokers; appendix).

Only 28·8% (95% CI 19·7–40·0) of people with asthma (29·3% of men and 28·2% of women) reported ever being diagnosed with asthma by a physician, and 23·4% (30·4% of men and 14·3% of women) reported ever having had a pulmonary function test (figure 1). An even smaller proportion (5·6%; 5·9% of men and 5·3% of women) reported having been treated with inhaled corticosteroids (figure 1) and even in people with asthma diagnosed by physicians, only 10·2% had received therapy with inhaled corticosteroids (appendix).

People with asthma with airflow limitation had a higher proportion of blood eosinophil counts of more than 5% than both people with asthma without airflow limitation and those without asthma (asthma with airflow limitation *vs* asthma without airflow limitation p=0·025, and asthma with airflow limitation *vs* no asthma p=0·017) as well as a higher proportion of a positive bronchodilator reversibility (asthma with airflow limitation *vs* asthma without airflow limitation p=0·003, and asthma with airflow limitation *vs* no asthma p<0·0001; figure 2). Compared with people without asthma, those with asthma had an impaired health state (p<0·0001 and p=0·0007) as measured by the PCS and MCS scores of the SF-12 questionnaire (figure 2B). Furthermore, people with asthma with airflow limitation had lower PCS scores than those with asthma without airflow limitation (mean PCS scores of 43·6 *vs* 46·9 points, p=0·002), but the mental health state of those with asthma with and without airflow limitation was not significantly different (mean MCS scores of 51·3 *vs* 51·0 points, p=0·86).

Among people with asthma, 15·5% reported at least one emergency room visit and 7·2% reported at least one hospital admission in the past 12 months due to an

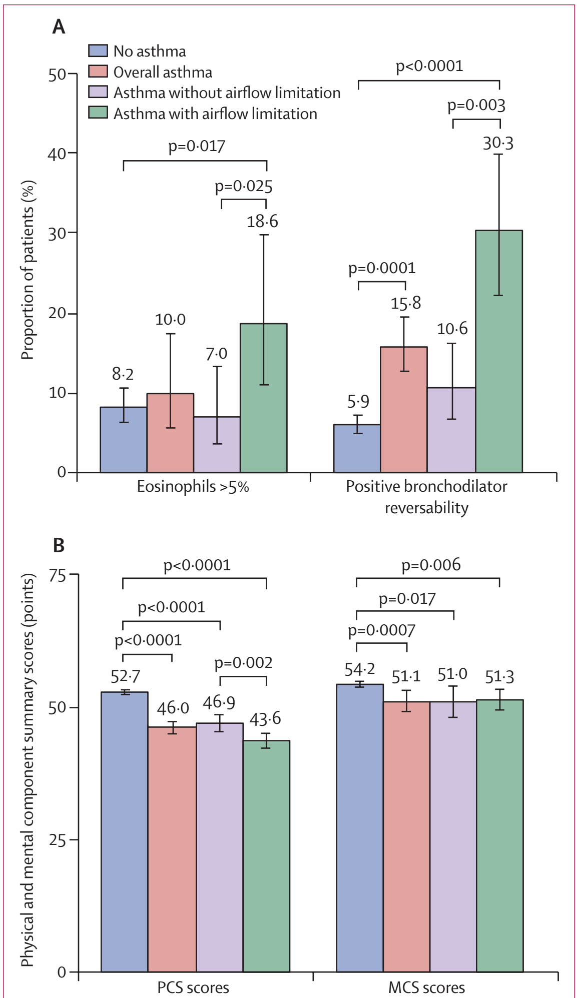


*Figure 2:* **Comparison of blood eosinophil concentrations and bronchodilator reversibility (A) and quality of life (B) in people with and without asthma**
A positive bronchodilator reversibility test was defined as an increase in post-bronchodilator forced expiratory volume in 1 s of more than 12% and more than 200 mL from baseline, 20 min after inhalation of 400 μg of salbutamol. Quality of life was assessed by the physical and mental component summary scores of the 12-item Short Form Health Survey.[20]

| | Overall asthma (n=2032) | Asthma without airflow limitation (n=1362) | Asthma with airflow limitation (n=670) | p value |
|---|---|---|---|---|
| Duration of wheezing years | 11·8 (1·1) | 9·7 (1·0) | 16·6 (1·4) | 0·0002 |
| Physician-diagnosed asthma | 514 (28·8%) | 292 (29·1%) | 222 (27·8%) | 0·90 |
| Medication use | | | | |
| Inhaled corticosteroid | 151 (5·6%) | 83 (4·5%) | 68 (8·8%) | 0·20 |
| Inhaled bronchodilator | 221 (8·0%) | 103 (5·6%) | 118 (14·2%) | 0·042 |
| Aminophylline | 231 (8·9%) | 96 (4·0%) | 135 (20·6%) | 0·0002 |
| Systemic corticosteroid | 129 (5·2%) | 60 (3·6%) | 69 (9·1%) | 0·0028 |
| Antibiotics | 474 (19·5%) | 291 (18·3%) | 183 (22·4%) | 0·46 |
| Exacerbation of respiratory symptoms in the preceding 12 months | | | | |
| Emergency department visit | 365 (15·5%) | 191 (12·9%) | 174 (22·8%) | 0·0094 |
| Hospital admission | 163 (7·2%) | 62 (4·2%) | 101 (15·7%) | 0·0001 |

Values are weighted and shown as number (%) or mean (SE). All calculations of p values are weighted, accounting for the multistage cluster sampling design and based on Student's *t* test. Overall asthma was defined as physician-diagnosed asthma or wheeze in the preceding 12 months. Airflow limitation was defined as post-bronchodilator $FEV_1$/FVC of <70%.

*Table 4:* **Use of health-care resources by people with asthma**

exacerbation of respiratory symptoms. Compared with people without airflow limitation, those with asthma with airflow limitation had a longer duration of wheezing (16·6 years *vs* 9·7 years, p=0·0002), and were more likely to have exacerbations (22·8% *vs* 12·9% reported at least one emergency room visit, p=0·009; 15·7% *vs* 4·2% reported at least one hospital admission, p=0·0001; table 4).

## Discussion

Our large comprehensive asthma survey in a nationally representative sample of Chinese adults indicated that asthma is a major public health challenge in China that affects 45·7 million adults aged 20 years or older. Previous studies have reported a lower prevalence of asthma and estimated that approximately 30 million children and adults have asthma in China.[6,7,9] Our study, which used a stringent sampling design and standard methods for asthma assessment, provides an accurate estimate of the asthma burden in China. Consistent with previous studies,[2,4] we did not use positive bronchodilator reversibility to define asthma, although it is an informative clinical variable, because earlier studies have shown that a positive bronchodilator reversibility is neither necessary nor sufficient for asthma diagnosis.[23] Our estimated prevalence of physician-diagnosed asthma was 1·2%, which is very similar to the value of 1·2% reported by Lin and colleagues[9] on the basis of data from participants aged 14 years or older from eight provinces and municipalities. However, our estimated prevalence of asthma of 4·2% based on wheezing and physician diagnosis was lower than the value of 5·8% reported by Wang and colleagues[10] in a phone interview study of adults aged 16–65 years from 18 major cities in China.[10] Although the demographic characteristics of the participants in these studies were not completely matched, the higher prevalence reported by Wang and colleagues[10] might be partly explained by their relaxed diagnostic criteria based on asthma-like symptoms. Our results indicate that the discrepancy in the prevalence of asthma reported by previous studies is largely due to differences in the definition of asthma.

Asthma was identified by the Global Burden of Disease study as being the most globally prevalent chronic respiratory disease, affecting 358 million people in 2015.[2] Although a prevalence of 4·2% is still lower than the estimates based on the ECRHS questionnaire in many high-income countries, such as Italy (9·0%), Germany (9·3%), Japan (10·1%), France (15·2%), the UK (22·6%), and Australia (27·4%),[4,24] the prevalence of asthma in China is likely to increase rapidly because of fast changes in environment and lifestyle, as well as the ageing population.

To our knowledge, our study is the first survey reporting asthma with airflow limitation in China, showing a prevalence of 1·1%. We found that 26·2% of adults with asthma had airflow limitation, which was similar to the 21·7% reported in adults from six low-income and middle-income countries,[25] and was much higher than the 16·2–18·8% reported in developed high-income countries.[26,27] The relatively high proportion of airflow limitation in people with asthma in China might be attributed to undertreatment of asthma, such as underuse of inhaled corticosteroids. Asthma with airflow limitation is likely to represent the overlap phenotype of asthma and chronic obstructive pulmonary disease and possibly an early form of the latter.

We identified several risk factors associated with asthma in the Chinese population. First, the prevalence of asthma increased with age. Asthma is often considered a childhood disease, but previous epidemiological studies have showed that asthma is also common in people aged 60 years or older.[6–9,28] Asthma in older people might develop either early in life or at an advanced age. It has been found that late-onset asthma is associated with increased morbidity and mortality than early-onset asthma.[29] Second, both allergic rhinitis and cigarette smoking were found to be important risk factors for asthma and asthma with airflow limitation.[9,28,30] Nevertheless, allergic rhinitis had a weaker effect (OR=1·70 *vs* 3·53) and was less common in people with airflow limitation than in those without airflow limitation (16·7% *vs* 30·4%, p=0·004), consistent with a previous report.[31] Ever-smokers had double the risk of developing asthma compared with never smokers. Given the high prevalence of cigarette smoking in Chinese men, smoking prevention and cessation should be a crucial strategy to reduce asthma in China.

Conflicting results have been reported regarding the association of biomass use with asthma prevalence.[32,33] We found that the association of biomass use with asthma was only significant in never-smokers, suggesting that the risk of biomass use might be masked by the stronger effect of smoking in the general population. Similarly, we found a significant association between asthma prevalence and exposure to high concentrations of $PM_{2·5}$ and mould in the home only in never-smokers. These findings support previous studies done in European populations. For example, one study[34] reported that exposure to ambient particulate matter was associated with wheezing and shortness of breath, whereas another study[35] showed that damp housing was associated with an increased prevalence of asthma. We also found that education attainment was inversely associated with the risk of asthma in accordance with other studies.[36,37] Finally, we found that the prevalence of asthma was higher in both underweight and overweight respondents than in those with normal weight, indicating that bodyweight could be a key modifiable risk factor.[38]

Our study found that in people with asthma only 28·8% had been previously diagnosed and 23·4% had ever undergone pulmonary function tests, which might be a consequence of poor awareness of asthma in both patients and physicians, and poor access to health-care facilities and medical consultation, especially in underdeveloped regions of China. The proportion of asthma respondents who used therapy with inhaled corticosteroids was only 5·6%, or 10·2% if only physician-diagnosed patients with asthma were considered. However, this proportion was still much lower than the proportions reported in some European countries. For example, the ECRHS study showed that the use of inhaled anti-inflammatory medication (primarily corticosteroids) in patients with physician-diagnosed asthma ranged from 17% in Italy to 49% in the UK.[39] These data suggest that asthma is largely underdiagnosed and undertreated in China, which might be because of the underdevelopment of primary care services that can have an important role in reducing the asthma burden. Primary care services, especially in rural and remote regions, are lacking medical professionals, essential equipment (eg, spirometers), and medicines (eg, inhaled corticosteroids) for proper asthma diagnosis and treatment. The fact that asthma is underdiagnosed and undertreated might contribute to its high exacerbation rates. Indeed, the proportion of people with asthma experiencing an exacerbation (including an emergency room visit) in the preceding 12 months was 15·5% in China compared with only 8·4% in the UK.[40] In addition to improving primary care services, the use of self-management action plans as advocated by the Global Initiative for Asthma[1] is important for better asthma control and needs to be established urgently in China.

There are several limitations to our study. First, we did not include individuals younger than 20 years, thus we cannot provide information on children. Second, similar to other large-scale population-based surveys, the diagnosis of asthma was based mainly on a standardised questionnaire, which could potentially have led to the misclassification of chronic obstructive pulmonary disease as asthma because both diseases present with wheezing, especially in people aged 40 years or older or cigarette smokers. However, our results also showed that in these individuals, other asthma-related traits, such as allergic rhinitis and positive bronchodilator reversibility, were more common in those with asthma with airflow limitation than those who have airflow limitation without having asthma (appendix). Additionally, although most patients with asthma with airflow limitation were older than 40 years at the time of the study, we found that 41·0% of them had started to wheeze before that age, suggesting that they were unlikely to have chronic obstructive pulmonary disease. Another limitation of questionnaire-based diagnosing is that we might have missed those with cough-variant asthma, which is a subtype of asthma presenting with cough but with no wheeze, that accounts for 32·6% of patients with chronic cough in China.[41] We note that the prevalence of chronic cough was reported to be 3·3% in college students in south China,[42] but no statistics are available for the general Chinese population. By contrast with misclassification of chronic obstructive pulmonary disease, which can lead to an overestimation of asthma prevalence, we might have underestimated the prevalence of asthma by missing the cough-variant subtype, especially in regions with low health-care resources. Finally, our air pollution data only included $PM_{2·5}$, so we could not assess the effects of other air pollutants, such as ozone, on asthma.[34]

Our findings call for national efforts to improve the prevention, detection, and treatment of asthma in China. Smoking cessation, control of the use of biomass fuels, reducing air pollution, and increasing the awareness of asthma are important public health priorities to reduce the burden of asthma in China.[43]

**Contributors**

KH, TY, JX, LY, JZha, XianZ, CB, JK, PR, HS, FW, YC, TS, GS, YLi, GX, SW, JZhu, JH, and CheW conceived and designed the study. CheW supervised the study. GX and GS did the statistical analysis. All authors contributed to data collection, analysis, and interpretation. KH, ChaW, TW, KFC, JH, and CheW drafted the 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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