

ORIGINAL ARTICLE

The changing epidemiology of asthma in Shanghai, China

Fengying Zhang, MD¹, Jingqing Hang, MD¹, Buyong Zheng, MD¹, Li Su, MS², and David C. Christiani, MD, PhD^{2,3}

¹Department of Respiratory Medicine, Shanghai Putuo District People's Hospital, Shanghai, China, ²Environmental and Occupational Medicine and Epidemiology Program, Department of Environmental Health, Harvard School of Public Health, Boston, MA, USA, and ³The Massachusetts General Hospital and Harvard Medical School, Boston, MA, USA

Abstract

Objective: To investigate the prevalence of bronchial asthma in Putuo district in Shanghai, China. **Methods:** Cross-sectional, community-based study was performed with random sampling of a district with a population of one million. The subjects were residents of the district and six or more years of age. Questionnaire and spirometry were completed in all subjects. Asthma was defined as physician-diagnosed asthma. The results were compared with the asthma study of 40 000 population completed by the same team in Pudong area of Shanghai in 1997. **Results:** We surveyed 27 042 participants. The prevalence of asthma was 1.8% (488/27 042), much higher than the 0.41% (163/40 000) found in the 1997 survey in Pudong area of Shanghai. In subjects with asthma, current smoking, obesity, gender distribution and the combination of allergic diseases between the two studies had no differences. The most prominent causes of asthma exacerbation were cold air, respiratory infection and dust inhalation. Pulmonary function for 428 asthma patients in Putuo survey was analyzed: 228 (53.3%) patients had FEV1%pred lower than 80%. Asthmatics older than 65 years had lower FEV1%pred than other age groups ($p < 0.01$). **Conclusions:** The prevalence of physician-diagnosed asthma in urban of Shanghai has increased in recent years. The most important causes of asthma exacerbations were cold air, respiratory infection and dust exposure. The proportion of individuals with decreased percent predicted forced expiratory volume of first second increased with age. Strengthening the prevention and treatment of asthma, especially in children with asthma, may decrease the health burden of asthma in the urban Chinese population.

Keywords

Asthma, China, epidemiology

History

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Introduction

Asthma is one of the most prevalent chronic respiratory diseases, affecting almost three-hundred million people in the world [1]. The prevalence of asthma has increased in many countries and areas. Asthma prevalence has increased from 7.4% in 2001 to 8.2% in 2009 in the United States [2]. In Australia, the prevalence increased from 6% in 1996 to 19% during 2005–2007 [3]. The International Study of Asthma and Allergies in Children investigated the prevalence of asthma in many countries for years and showed an increase in the prevalence of asthma and wheezing in the most recent phase III survey when compared with phase I [4]. In China, the prevalence of asthma varies in different areas and ethnic groups. A survey on the prevalence of bronchial asthma in Beijing area among the residents aged over 14 years from 2010 to 2011 showed the overall prevalence rate of asthma was 1.19% (687/57 647) [5]. Other studies in Jinan and Li ethnic group in Hainan showed asthma prevalence was 1.1% and 3.38%, respectively [6,7].

Previously, we conducted an asthma study in Pudong Area of Shanghai in 1997. The prevalence of asthma then was 0.41% [8]. This survey was done to assess whether the prevalence of asthma increased after a decade using the same methodology. We completed a cohort study in Putuo District in Shanghai during the period of August 2007 to January 2010. Our aim was to evaluate the epidemiology of asthma in Shanghai and to determine if the prevalence of asthma increased in there during these years.

Methods**Study design and data collection**

The Shanghai Putuo study, collaboration between Harvard School of Public Health and Shanghai Putuo District People's Hospital, recruited subjects from August 2007 to January 2010 from Putuo District in Shanghai, China. The Institutional Review Board of the Harvard School of Public Health and Putuo District People's Hospital approved this study. Study subjects were recruited based on random selection from census track data with following eligible criteria: age six years and older with no restrictions with regard to prior health history. Of the total 34 022 subjects, 6980 subjects refused to participate in this study, 27 042

Correspondence: Jingqing Hang, MD, Department of Respiratory Medicine, Shanghai Putuo District People's Hospital, Shanghai, China. Tel: 86-21-32274550-5533. E-mail: hangjq@hotmail.com

subjects (79.5%) provided written informed consent to participate and completed the baseline clinical examination and questionnaire. Putuo District is located northwest of the central area of Shanghai, China. In 2010, the region's total registered population was about 1.17 million [9].

All subjects were interviewed in person by trained personnel using structured questionnaires. The questionnaires include socio-demographic factors (age, gender, education, marital status and household income), smoking history (smoking status, pack-years of smoking and second-hand smoke), occupational history and medical history. Respiratory disease history, allergic history and family history were asked if the subject reported respiratory symptoms in the prevalence survey. The St. George's questionnaire (SGRQ) [10] was used to assess the quality of life in these subjects and a total score was compared; 100 represents worst possible health status and 0 indicates best possible health status. Asthma, allergic rhinitis (AR), eczema and chronic urticaria were self-reported physician-diagnosis. Asthma exacerbation was defined as going to emergency department or being hospitalized because of wheezing, cough or chest tightness.

Blood pressure, height, weight and waist circumference were measured during the physical examination. Pulmonary function was tested using the Micro Plus hand held spirometer (Micro Medical Limited, Rochester, England, UK). The forced expiratory volume of first second (FEV1) and forced vital capacity were recorded. All subjects were tested at least three times, and the best acceptable values were recorded.

The Shanghai Pudong study was completed from January 1997 to December 1998 in the Pudong Jinqiao area in Shanghai. The study design was similar to the Shanghai Putuo study. The Pudong Jinqiao area is located southeast of the central area of Shanghai. The characteristics of the populations in these two areas were similar. Asthma was defined as physician-diagnosed asthma, and all asthmatics completed spirometry tests.

Statistical analysis

All data were entered using Epidata (Epidata Association, Denmark). Statistical analyses were performed using SPSS, version 16.0 (SPSS Inc., Chicago, IL). Data were presented as mean $\pm$ standard deviation or percent of total number. The main analysis was chi-square test. $p < 0.05$ was considered to be statistically significant. FEV1 was described as the percent of predicted lung function, which adjusted for age and height.

Results

Demographic characteristic of survey population

Demographic characteristics of the survey population are listed in Table 1. The study population consisted of 12 519 males (46.3%) and 14 523 females (53.7%). The range of age was 6–102 years. Mean age was 47.0 ± 18.9 years, and 16.5% of subjects had received a university education. The proportions of subjects who graduated from the junior high school, senior high school and junior college were 25.5%, 28.7% and 13.8%, respectively. Common current occupations were professional, office and retired (20.2%, 11.6% and 37.9%,

Table 1. Demographic characteristics of the population.

Variables	Results
Number	27 042
Gender (%)	
Male	46.3
Female	53.7
Age (years), mean $\pm$ SD	47.0 ± 18.9
Education level (%)	
Illiteracy	4.4
Primary school	11.1
Junior high school	25.5
Senior high school	28.7
Junior college	13.8
University or graduate school	16.5
Occupation (%)	
Agriculture	0.5
Worker	5.6
Professional	20.2
Office	11.6
Service	6.0
Housework	2.2
Retired	37.9
Others	15.8
Smoking status (%)	
Current smokers	21.3
Ex-smokers	3.8
Non-smokers	74.9
BMI (%)	
Normal	74.7
Over weight	22.5
Obesity	2.8

respectively). The proportions of current smokers and ex-smokers were 21.3% and 3.8%, respectively.

Over weight and obesity in adults was defined according to the WHO standard [11]. BMI between 25 and 29.9 kg/m^3 is defined as overweight, and $\text{BMI} \geq 30 \text{ kg/m}^3$ is defined as obese. Overweight and obesity in subjects younger than 18 years was defined according to the standard established by Working Group on obesity in China [12]. The percent of overweight and obesity in the study population was 22.5% and 2.8%, respectively.

Asthma prevalence

A physician-diagnosis of asthma was reported by 488 subjects, yielding a prevalence of 1.8%. The prevalence in males was 2.1% (264/12 519), higher than the prevalence in females, which was 1.5% (224/14 523), $p < 0.01$. The ratio of asthma prevalence in males and females was 1.4:1.

The prevalence of asthma in males younger than 18 years was 5.2%, and 2.4% in females of same age ($p < 0.01$). The prevalence in males and females was 1.8% and 1.5%, respectively, between 19 and 64 years of age ($p > 0.05$). The prevalence of asthma was 2.1% and 1.3% in male and female subjects older than 65 years of age ($p < 0.05$). The change of asthma prevalence by gender and age is shown in Figure 1.

Asthma prevalence in subjects with normal BMI was 1.7% (350/20 216), while in over weight subjects, 1.9% (114/6079) reported asthma. The proportion of asthma increased to 3.2% (24/747) in subjects with obesity, and was statistically different compared with the prevalence among subjects who were either normal BMI ($p < 0.01$) or overweight ($p < 0.05$).

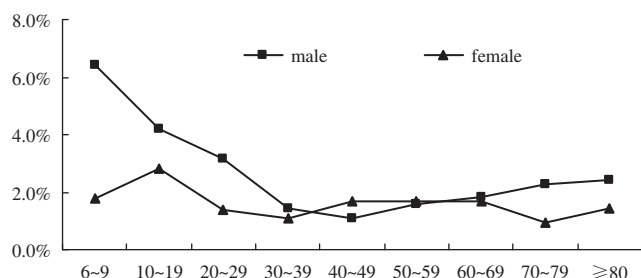


Figure 1. Asthma prevalence at different ages by gender.

Table 2. Asthma prevalence in subjects with different BMI.

BMI	Asthma (n)	Non-asthma (n)	Asthma prevalence (%)
Normal	350	19 866	1.7%
Over weight	114	5965	1.9%
Obesity	24	723	3.2%

The asthma prevalence in subjects with normal BMI had no difference compared with subjects of overweight ($p > 0.05$). The asthma prevalence in subjects with obesity was higher than in subjects with normal BMI ($p < 0.01$) and subjects of overweight ($p < 0.05$).

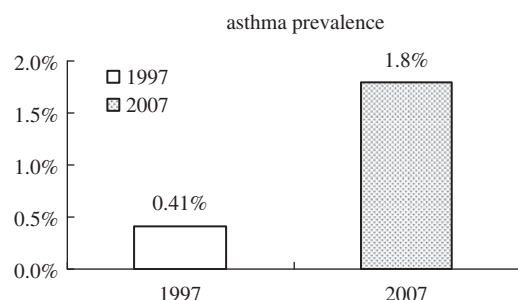


Figure 2. Comparison of asthma prevalence between 1997 and 2007 surveys.

The prevalence of asthma in subjects with various BMI is listed in Table 2.

The prevalence of asthma in the Pudong Survey in 1997 was 0.41%. The prevalence in males and females was 0.39% and 0.42%, respectively, ($p > 0.05$). A comparison of asthma prevalence of 2007 survey and 1997 survey is shown in Figure 2.

Asthma accompanied by other allergic diseases

Results revealed the following proportions: 35.4% AR, 9.0% eczema and 3.5% chronic urticaria, respectively, among the 488 asthma patients. The proportions of AR, eczema and chronic urticaria in the total population were 4.5% (1214/27 042), 0.9% (232/27 042) and 0.7% (197/27 042), which were significantly lower than in asthma patients ($p < 0.01$).

Family history of asthma in asthmatics

A total of 39.3% of asthma patients reported a family history of asthma. Maternal asthma was reported at a prevalence of 11.7%, which was the highest among other family members. The next most common was father, which was 10.5%.

Table 3. Mean age and asthma duration by FEV1.

FEV1%pred	Mean age (year)	Asthma duration (year)
FEV1%pred $\geq 80\%$	41.3 ± 16.0	25.6 ± 15.0
FEV1%pred 60–79%	47.2 ± 16.4	30.3 ± 17.0^a
FEV1%pred 40–59%	58.1 ± 15.5	32.7 ± 17.8^a
FEV1%pred $< 40\%$	65.9 ± 13.9	29.8 ± 20.0

^aAsthma duration was significantly different compared with patients of FEV1%pred $\geq 80\%$ ($p < 0.05$).

Causes of asthma exacerbations

The questionnaire queried the cause of asthma exacerbation as follows: what situations will cause an asthma attack? Each asthma patients may select more than one cause. In this study, the most common causes of asthma exacerbations were cold air inhalation, respiratory infection, dust inhalation and exercise. The percentage reported of each was 67.6%, 55.6%, 30.9% and 16.5%, respectively.

Pulmonary function

Since children younger than 12 years have no reference value of pulmonary function, the pulmonary functions of these subjects were not analyzed. Excluding those with poor test performance and subjects who refused testing, 428 subjects with acceptable pulmonary functions were analyzed; 228 (53.3%) subjects had a FEV1% predicted lower than 80%. We stratified these asthma patients into three groups according to age: 12–18 years, 19–64 years and older than 65 years. In these three groups, the average FEV1%pred predicted was $84.6 \pm 11.4\%$, $77.5 \pm 20.1\%$ and $55.0 \pm 24.0\%$, respectively. FEV1%pred of the elderly group was significantly lower than other two groups ($p < 0.01$). The percentage of subjects in these three groups with abnormal FEV1%pred was 27.3% (9/33), 50.2% (167/333) and 83.9% (52/62), respectively.

Functionally, the subjects were divided into four groups according to FEV1%pred: group I: FEV1%pred $\geq 80\%$; group II: FEV1%pred 60–79%; group III: FEV1%pred 40–59%; and group IV: FEV1%pred $< 40\%$. The mean age and asthma duration of each group are listed in Table 3. The lower FEV1%pred, the older mean age. The correlation coefficient between FEV1%pred and age was -0.48 , while it was -0.15 between FEV1%pred and asthma duration.

Quality of life

The average SGRQ score of these asthma patients was 14.0 ± 1.9 . With aging, the mean SGRQ score increased. SGRQ score in subjects older than 65 years was significantly higher than in subjects younger than 18 years, as well as in the younger age group of 19–64 years. The mean SGRQ scores of these three groups were 34.6 ± 22.9 , 6.7 ± 7.2 and 11.0 ± 16.5 , respectively. Pulmonary function had a positive correlation with quality of life ($r = 0.41$, $p < 0.001$).

Subjects with asthma compared between the two surveys

Characteristics of subjects with asthma in the two surveys were compared (Table 4). The mean age of asthma subjects in

Table 4. Comparison of characteristics of subjects with asthma in Pudong survey and Putuo survey.

	2007 Putuo survey (n = 488)	1997 Pudong survey (n = 163)	p Value
Mean age (year)	43.5 ± 21.1	34.2 ± 19.4	<0.01
Male/female (%)	54.1/45.9	47.2/52.8	>0.05
Current smoking (n, %)	113 (23.2)	31 (19.0)	>0.05
Obesity (n, %)	24 (4.9)	11 (6.7)	>0.05
Combined with allergic diseases (n, %)	226 (46.3)	85 (52.1)	>0.05

Table 5. Comparison of asthma prevalence and air pollution between 1997 and 2007 in Shanghai.

	2007	1997
Asthma prevalence	1.8% (488/27 042)	0.4% (163/40 000)
SO ₂ (mg/m ³)	0.055	0.032
Acid rain frequency	75.6%	11.0%
Rain pH	4.55	5.71

the Putuo survey was significantly older than asthma subjects in the Pudong survey. Gender distribution, the percent of current smoking and obesity as well as with allergic diseases all were not different between the two surveys.

Discussion

Asthma prevalence varies between and among countries and areas. The results of surveys conducted in different provinces in China are also not uniform. The surveys in Liaoning province in 1999, Henan province in 2000 and Beijing Area in 2010 showed that the asthma prevalence was 1.25%, 1.05 % and 1.19%, respectively [5,13,14]. Our survey showed the asthma prevalence was 1.8%. Of note, our current result was 4.4 times higher than a previous Pudong Jinqiao survey in Shanghai in 1997 that reported 0.41% [8]. These two areas are both in the downtown area of Shanghai with similar population characteristics. These two surveys were done by the same team and used the same methods and diagnostic criteria. The results of these two investigations showed that asthma prevalence in urban Shanghai has increased markedly since 1997.

The cause of increasing asthma prevalence still remains unknown. Proposed contributing factors have included exposure to air pollution, infections, and microbial substances in the environment [15]. According to the reports of Shanghai Environmental Protection Bureau [16], the average sulfur dioxide concentration in the ambient air in 2007 in Shanghai was 0.055 mg/m³, which was higher than the 0.032 mg/m³ in 1997. The frequency of acid rain in 2007 increased to 75.6%, while it was 11.0% in 1997. The pH of the rain decreased from 5.7 in 1997 to 4.6 in 2007 (Table 5). Respirable suspend particulate matter was measured in 2007, but only suspend particulate matter was monitored in 1997, so particulate matter in the atmosphere could not be compared.

Allergy and obesity are other potential etiologic factors that have become more common, which could have contributed to the increase of asthma [17,18]. In this study, the asthma prevalence in subjects with obesity was

significantly higher than in subjects without obesity. But the proportion of obesity in subjects with asthma was not different between the Putuo and Pudong surveys. The improvement of diagnosis in asthma has decreased misdiagnosis and under-diagnosis in asthma, which may lead to a bias of asthma prevalence compared with asthma studies before [19]. However, most asthma diagnosis in our population was made by secondary and tertiary hospitals in Shanghai and according to asthma guidelines established by Chinese Medical Association.

In this survey, asthma prevalence was bimodal: highest in children younger than 18 years, then declined with age, then increased in males older than 65 years. We conducted another survey of asthmatics in primary and middle school students in 2007, in which we found that 28.8% (81/281) children had disease remission at different ages, most commonly at 6–8 years and 12–13 years [20]. Some asthma patients had remission in adolescence, which may be one of reasons that asthma prevalence in adults was found to be lower than in children. Asthma in older people is common. The prevalence of asthma in elderly is also different in different countries and areas. Arif et al. showed that the estimated prevalence of current asthma in the elderly Hispanic and non-Hispanic white population was 6.3% [21]. Investigation of asthma completed in Liaoning province showed asthma prevalence in the elderly was 4.09%, higher than 1.25% in the overall subjects, and the prevalence in women was higher than in men [22]. In this study, asthma prevalence in elderly men was 2.10%, higher than the 1.80% in the whole population. It was also higher than the 1.31% in elderly women. This may be correlated with smoking prevalence in elderly men. Asthma combined with chronic obstructive pulmonary disease (COPD), or COPD misdiagnosed as asthma, should be considered in the elderly men as influencing the prevalence of asthma in such a population.

Asthma prevalence differs with gender, with males higher than females. Asthma epidemiology studies completed in China showed different results among genders. Asthma prevalence in males was lower than in females in both the Beijing [5] and Liaoning [13] surveys with ratios 1:1.32 and 1:1.64, respectively. But the results in the southern provinces of Guangdong [23] and Henan [14] surveys showed that asthma prevalence in males was higher than in females with the ratios 1.38:1 and 1.23:1.

Asthma is usually accompanied by other allergic diseases, and our results are consistent with other studies. Epidemiologic studies showed that about 30–80% asthma patients also have AR [14,20,24], supporting the hypothesis that asthma and AR are “one airway, one disease” [25]. Effective AR control is one of method of asthma control.

The most popular triggers of asthma attacks in our survey were cold air, respiratory infection and dust. Asthma is also often an allergic disease. Cold exposure may cause airway contraction and asthma attack [26]. Respiratory infection, especially viral infection, is a common precipitant of an asthma attack [27]. There are large concentrations of dust mites in the Shanghai area, which is one of main allergens for asthma. We did skin tests in asthma patients in the Pudong Jinqiao survey in Shanghai in 1997 and showed that 73.1% of asthma patients had a positive reaction to mites, significantly

higher than other allergens [8]. Hence, respiratory infection prevention and treatment, reducing cold air and dust exposures are effective methods to reduce asthma attacks.

The Global Initiative for Asthma proposes one of the goals of asthma control is to maintain pulmonary function near normal [28]. The results of PFTs in our study showed over 50% of asthmatics had impaired lung function, especially in patients older than 65 years. However, asthma duration was not associated with FEV1%pred. Such results might be related to the poor control of asthma. A survey of the Asia-Pacific region in 2011 showed that 42% patients reported uncontrolled asthma in the previous month and only 15% of the patients use inhaler regularly in the survey population in China [29]. In a survey in primary and middle school students in 2007, we found that the percentage of patients with standard treatment of asthma was very low; there were only 22.2% asthma patients using an inhaled corticosteroid in patients with asthma control test score under 19 [15]. Hence, an important goal is to achieve asthma control earlier can maintain pulmonary function normal or near normal and improve life quality of asthma patients.

The study of Pereira et al. [30] showed the SGRQ score in moderate and severe asthma was 31.9 ± 20.2 . Subjects with asthma in our survey had different conditions of disease, some were well controlled. The SGRQ score (14.0 ± 1.9) in our survey was lower than the study of Pereira et al. But the SGRQ score was increased in patients older than 65 years in our study, and most of these patients had an abnormal FEV1%pred.

In conclusion, the prevalence of asthma in urban Shanghai has increased substantially over the past decade. Strengthening the prevention and treatment of asthma, improving asthma symptoms, maintaining pulmonary function near normal, especially in children with asthma, may decrease the burden of asthma in Shanghai.

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Declaration of interest

The authors declare no potential conflicts of interest.

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