

High prevalence of current asthma and active smoking effect among the elderly

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Summary

Background Although asthma is a common cause of morbidity in adults, relatively few objectively measured population studies of asthma prevalence in adult populations have been conducted.

Objective To evaluate the prevalence of asthma, based on both a questionnaire and methacholine bronchial provocation test, and to determine the risk factors of asthma prevalence in an adult population.

Methods A total of 2467 adults, who were randomly selected from metropolitan urban, non-metropolitan urban and rural areas, responded to the modified ISAAC questionnaire, and underwent methacholine bronchial provocation tests and skin prick tests to locally common aeroallergens.

Results The prevalence of current asthma based on the questionnaire and the methacholine challenge was 2.0% in adults younger than 40, 3.8% in 40- to 54-year-olds, 7.7% in 55- to 64-year-olds and 12.7% in those aged 65 or higher. For subjects of 55–64 years, active smoking was found to be significantly related with the prevalence of current asthma and bronchial hyper-responsiveness, although smoking was positively associated with percentage predictive value of forced expiratory volume of 1 s (FEV₁).

Conclusion The prevalence of current asthma is common among the elderly, and active smoking may play an important role in the development of asthma and bronchial hyper-responsiveness among the elderly.

Keywords adult, asthma, atopy, bronchial hyper-responsiveness, smoking

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Introduction

Asthma is a world-wide problem and is considered more common in developed countries than in developing countries [1]. The prevalence of asthma has been estimated from surveys using questionnaires, spirometry and bronchial hyper-responsiveness (BHR) assessments. Prevalence estimates based on questionnaires may be affected by the wording of the questions concerning asthma. For all ages, physician-diagnosed asthma occurs less frequently than wheezing, and half of those with a physician's diagnosis have active asthma [2]. As opposed to the use of questionnaires, the direct measurement of bronchial responsiveness has the potential to provide an objective measure of asthma prevalence. Methacholine, histamine, exercise and cold air have been used in various studies to induce BHR [3]. However, BHR is only one component of the asthma phenotype; and many people with BHR never experience asthma attacks or symptoms [4, 5].

Although asthma is a common cause of morbidity in adults, the perception remains that asthma is a childhood disease. Its incidence is higher in children than in adults [6] and remissions are unlikely after 30 years of age [7]. In children, there is an association between the presence of atopy and BHR [5], both of which are associated with the persistence of wheezing into later childhood [8]. However, relatively few population studies have utilized objective measures of asthma prevalence in adult populations, although we have reported upon the prevalence of asthma, based on a questionnaire and methacholine bronchial provocation test in children [9]. The present survey was performed to evaluate the prevalence of current asthma, based on both a questionnaire and a methacholine bronchial provocation test, and to determine the risk factors, such as age, sex, atopy, smoking and spirometric lung function, of asthma prevalence in an adult population.

Methods

Study populations

A total of 2467 adults of over 20 years of age were enrolled in this study. All of the subjects were randomly recruited from a

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health service list, on the basis of the age profile of the general population, in the metropolitan city of Seoul, in the non-metropolitan cities of Cheonan and Icheon, and in an rural area, Goisan county, Korea. Of the subjects, 795 were living in a metropolitan city, 788 in non-metropolitan cities and 884 in rural areas. The male:female ratio was the same in all three groups. The questionnaire response rate was 2432 subjects of the 2467 subjects, 1858 underwent methacholine bronchial provocation tests and 2401 the skin prick tests to locally common aeroallergens. All subjects gave informed written consent and the study protocol was approved by the Ethics Committee of Seoul National University Hospital.

Methods

A modified questionnaire developed by the International Study of Asthma and Allergic diseases in Children (ISAAC) [10] was translated into Korean. The questionnaire included demographic data, asthma symptoms and various risk factors, especially active smoking history. Asthma symptom results were regarded as positive if a subject had experienced wheezing during the previous 12 months.

Forced expiratory volume in 1 s (FEV₁) and forced vital capacity (FVC) were measured with a portable spirometer (Micro Spirometer, Micro Medical, Rochester, Kent, UK), taking the largest values of triplicate FEV₁ and FVC measurements. Methacholine challenge was carried out using the method described by Chai et al. [11]. Subjects with respiratory tract infections during the two previous weeks were excluded to avoid false positive results, and those with a baseline FEV₁ of lower than either 1200 mL or 50% of the predicted value were also excluded to avoid misclassifying pure chronic obstructive pulmonary disease (COPD) as asthma. None of the subjects had received any bronchodilators or antihistamines for 5 days before the challenge. Concentrations of 1.25, 2.5, 6.25, 12.5 and 25 mg/mL of methacholine were prepared by dilution with buffered saline. A Rosenthal-French dosimeter (Laboratory for Applied Immunology, Baltimore, MD, USA) was used to deliver aerosols generated by a nebulizer (DeVilbiss, Carlsbad, CA, USA). Subjects inhaled five inspiratory capacity breaths of increasing methacholine concentrations either until the FEV₁ fell to less than 80% of its baseline value or until the highest concentration was reached. The largest value of the triplicate FEV₁ measurements made at 90 or 180 s after each inhalation was used for analysis. If the concentration of methacholine which caused a 20% fall in the FEV₁ (PC₂₀) was less than 25 mg/mL, the subject was considered to have BHR to methacholine. Current asthma was diagnosed if a subject had experienced current wheezing as reported on the questionnaire and had exhibited BHR to methacholine.

Skin prick tests were performed to determine atopy by using a panel of 12 common Korean aeroallergens. None of the subjects received antihistamines orally for the 4 days preceding the tests. The skin prick test panel consisted of house dust mites (*Dermatophagoides pteronyssinus*, *D. farinae*), cat fur, moulds (*Aspergillus fumigatus*, *Alternaria tenuis*), various pollens [tree pollen mixture 1 (alder, hazel, poplar, elm, and willow) and mixture 2 (birch, beech, oak, and plane tree), grass pollen mixture (velvet grass, orchard grass, rye grass, timothy grass, Kentucky blue grass, and meadow grass), mugwort, and ragweed], cockroach (*Blattella germanica*), and two-spotted spider

mite (*Tetranychus urticae*). A positive histamine control (1 mg/mL) and a negative diluent control were included in all tests. Fifteen minutes after the prick, the mean diameter of the weal formed by the allergen was compared with that formed by histamine. If the former was greater or equal to the latter (allergen/histamine ratio ≥ 1.0), the reaction was defined as positive. Atopy was defined to be present if a subject exhibited positive skin-test responses to any one or more of the 12 aeroallergens.

Statistical analysis

Data are expressed as means and SDs unless otherwise indicated. Statistical significances were assessed using the independent *t*-test and ANOVA for continuous variables, and the χ^2 and the χ^2 -trend tests for categorical variables. Multivariate logistic regression analysis was performed to evaluate the relationships between the prevalence of atopy, BHR and current asthma, and the risk factors identified by univariate analysis. As for dependent continuous variables, multivariate linear regression analysis was performed after the univariate analysis. A *P*-value of 0.05 or less was regarded as significant.

Results

Demographic and clinical characteristics of study populations according to age

Table 1 shows the demographic and clinical characteristics of the study populations according to the age groups. The rural population was older than the metropolitan and the non-metropolitan urban adults ($P < 0.001$), which indicates that age of the general population in Korea is higher in rural areas than in urban areas. Atopy rates and baseline spirometric lung function (FEV₁, % pred.) decreased with increasing subject age (both $P < 0.001$). However, the prevalences of current wheezing on the questionnaire and BHR to methacholine increased with increasing subject age ($P < 0.001$, respectively; Fig. 1). The prevalence of current asthma was 2.0% in subjects younger than 40, 3.8% in 40- to 54-year-olds, 7.7% in 55- to 64-year-olds and 12.7% in those 65 years and older, which confirmed that the prevalence of current asthma is positively correlated with subject age ($P < 0.001$) (Fig. 1). Active smoking and current smoking frequencies did not differ according to age.

Multivariate analysis of the relationships between atopy and risk factors (Table 2)

Multinomial logistic regression analysis was performed to evaluate the relationships between atopy and risk factors, such as age, sex, smoking status and place of residence. The rate of atopy decreased with increasing subject age after adjustment of the other risk factors ($P < 0.001$), and was higher in males than in females [odds ratio (OR) = 1.31, 95% confidence interval (CI) 1.01–1.7, $P = 0.04$]. In terms of place of residence, the rate of atopy was higher for residents of rural area than for those in metropolitan and non-metropolitan cities (OR = 1.74, 95% CI 1.35–2.23, $P < 0.001$; OR = 2.01, 95% CI 1.60–2.55, $P < 0.001$, respectively). However, the atopy rate was not related to active smoking status.

Table 1. Demographic and clinical characteristics according to age

	Age, years				P
	≤ 39 (n = 946)	40–54 (n = 887)	55–64 (n = 408)	≥ 65 (n = 225)	
Sex, female (%)	471 (49.7)	383 (43.2)	206 (50.5)	129 (57.3)	NS*
Residence					< 0.001†
Large city (n = 729)	340 (46.6)	254 (34.8)	106 (14.5)	29 (4.0)	
Small city (n = 1106)	466 (42.1)	385 (34.8)	148 (13.4)	107 (9.7)	
Rural (n = 632)	141 (22.3)	248 (39.2)	154 (24.4)	89 (14.1)	
Smokers	360 (38.5)	363 (38.8)	137 (34.9)	76 (35.2)	NS†
Ex-smokers	76 (8.2)	111 (12.9)	51 (13.3)	36 (17.1)	NS*
Current smokers	290 (31.3)	264 (30.7)	105 (27.4)	55 (26.1)	NS*
Atopy§	300 (32.5)	224 (26.0)	97 (24.4)	36 (16.9)	< 0.001†
FEV ₁ , % pred. (n = 1983)	96.8 ± 14.5	94.6 ± 16.8	92.8 ± 17.3	87.5 ± 18.7	< 0.001‡
Current wheezing¶	68 (7.2)	86 (10.0)	57 (14.3)	60 (27.1)	< 0.001†
BHR**	33 (5.2)	41 (5.8)	49 (14.4)	40 (23.1)	< 0.001†
Current asthma††	13 (2.0)	27 (3.8)	26 (7.7)	22 (12.7)	< 0.001†

Data are expressed as numbers of positive responders (%) or mean ± SD. * χ^2 trend test. † χ^2 and χ^2 trend test. ‡ANOVA and test for linearity. §Positive skin test responses to one or more common aeroallergens. ¶Wheezing during the previous 12 months on a questionnaire. **PC₂₀-methacholine < 25 mg/mL. ††Current wheezing and bronchial hyper-responsiveness to methacholine.

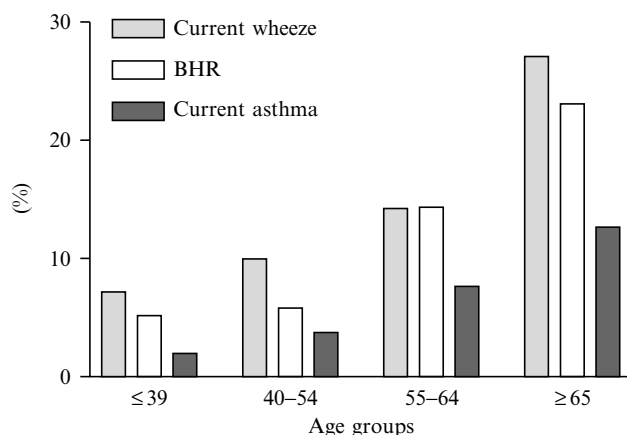


Fig. 1. Prevalence of current wheezing by questionnaire, bronchial hyper-responsiveness to methacholine and current asthma according to age. BHR, bronchial hyper-responsiveness to methacholine.

Multivariate analysis of the relationship between BHR and risk factors (Table 3)

Multinomial logistic regression analysis was performed to evaluate the relationship between bronchial responsiveness to methacholine and the risk factors, which included age, sex, smoking status, baseline spirometric lung function, place of residence and atopic status. Bronchial responsiveness to methacholine was found to increase with increasing subject age after adjustment for the other risk factors, and was negatively associated with percentage predictive value of FEV₁ ($P < 0.001$, respectively). BHR was higher in active smokers than in non-smokers (OR = 2.66, 95% CI 1.53–4.62, $P = 0.001$), and for the group of the active smokers, BHR was higher in the current smokers than in the ex-smokers (OR = 2.14, 95% CI 1.14–4.19, $P = 0.02$). In regard to place of residence, BHR was lower in residents of rural areas than in those of non-metropolitan

Table 2. Multivariate analysis of relationship between skin responses to common aeroallergens and risk factors

	Atopy*		P	OR (95% CI)
	Negative	Positive		
Age, years	45.3 ± 14.3	41.9 ± 13.5	< 0.001	
Sex				
Female	75.7	24.3		1.0
Male	69.6	30.4	0.04	1.31 (1.01–1.7)
Smoking				
Non-smokers	74.1	25.9		1.0
Smokers	70.7	29.3	NS	0.94 (0.72–1.22)
Ex-smokers	74.0	26.0		1.0
Current smokers	69.4	30.6	NS	1.14 (0.82–1.58)
Residence				
Large city	72.8	27.2		1.0
Small city	76.8	23.2		1.0
Rural	65.0	35.0	< 0.001†	1.74 (1.35–2.23)
			< 0.001‡	2.01 (1.60–2.55)

Data are expressed as percentage of responders or mean ± SD. OR, odds ratio; NS, not significant. *Positive skin test responses to one or more common aeroallergens. †P-value versus large city. ‡P-value versus small city.

cities (OR = 0.59, 95% CI 0.38–0.92, $P = 0.02$), but was the same for those living in rural and metropolitan areas (OR = 0.87, 95% CI 0.54–1.4). However, BHR was not dependent upon sex or atopic status.

Multivariate analysis of the relationship between current asthma and risk factors (Tables 4 and 5)

Table 4 shows the results of a multinomial logistic regression analysis of the relationships between current asthma and risk factors, such as age, sex, smoking status, baseline spirometric

Table 3. Multivariate analysis of relationship between bronchial responsiveness to methacholine and risk factors

	BHR*		<i>P</i>	OR (95% CI)
	Negative	Positive		
Age, years	44.7 ± 13.6	53.5 ± 14.7	< 0.001	
Baseline FEV ₁ , % pred.	96.0 ± 15.7	87.0 ± 15.8	< 0.001	
Sex				
Female	90.5	9.5	0.15	1.0
Male	91.9	8.1		0.67 (0.39–1.15)
Smoking				
Non-smokers	92.2	7.8	0.001	1.0
Smokers	89.9	10.1		2.66 (1.53–4.62)
Ex-smokers	93.6	6.4		1.0
Current smokers	88.5	11.5	0.02	2.14 (1.1–4.19)
Residence				
Large city	93.5	6.5	0.56† 0.02‡	1.0
Small city	89.3	10.7		1.0
Rural	90.5	9.5		0.87 (0.54–1.4) 0.59 (0.38–0.92)
Atopic status§				
Non-atopics	91.6	8.4	0.07	1.0
Atopics	90.7	9.3		1.42 (0.97–2.1)

Data are expressed as percentage of responders or mean ± SD. OR, odds ratio. *PC₂₀-methacholine < 25 mg/mL. †*P*-value versus large city. ‡*P*-value versus small city. §Skin test responses to one or more common aeroallergens.

Table 4. Multivariate analysis of relationship between current asthma and risk factors

	Current asthma*		<i>P</i>	OR (95% CI)
	Negative	Positive		
Age, years	45.0 ± 13.8	54.8 ± 13.2	< 0.001	
Baseline FEV ₁ , % pred.	95.7 ± 15.6	85.7 ± 17.8	< 0.001	
Sex				
Female	94.7	5.3	0.009	1.0
Male	95.9	4.3		0.38 (0.19–0.79)
Smoking				
Non-smokers	96.4	3.6	< 0.001	1.0
Smokers	94.0	6.2		4.83 (2.3–10.13)
Ex-smokers	95.6	4.4		1.0
Current smokers	93.2	6.8	0.13	1.88 (0.83–4.27)
Residence				
Large city	97.2	2.8	0.39† 0.57‡	1.0
Small city	94.5	5.5		1.0
Rural	93.6	6.4		1.33 (0.7–2.52) 0.85 (0.48–1.49)
Atopic status§				
Non-atopics	95.7	4.3	0.02	1.0
Atopics	94.4	5.6		1.8 (1.09–3.0)

Data are expressed as percentage of responders or mean ± SD. OR, odds ratio. *Current wheezing on a questionnaire and bronchial hyper-responsiveness to methacholine. †*P*-value versus large city. ‡*P*-value versus small city. §Skin test responses to one or more common aeroallergens.

lung function, place of residence and atopic status. The prevalence of current asthma increased with increasing subject age after adjust for the other risk factors, and was negatively associated with percentage predictive value of FEV₁ ($P < 0.001$, respectively). Interestingly, asthma prevalence was higher in females than in males (OR = 0.38, 95% CI 0.19–0.79,

$P = 0.009$), and higher in active smokers than in non-smokers (OR = 4.83, 95% CI 2.3–10.13, $P < 0.001$), but similar for ex- and current smokers. Regarding atopic status, asthma prevalence was higher in atopics than in non-atopics (OR = 1.8, 95% CI 1.09–3.0, $P = 0.02$), but was not dependent upon the place of residence.

Table 5. Multivariate analysis of relationship between current asthma and risk factors according to age

	Current asthma* according to age (years)							
	≤ 39		40–54		55–64		≥ 65	
	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)
Age	NS		NS		NS		NS	
FEV ₁ , % pred.	0.06		0.04		< 0.001		NS	
Sex								
Female		1.0		1.0		1.0		1.0
Male	NS	1.0 (0.87–1.06)	0.04	0.2 (0.05–0.9)	0.04	0.2 (0.05–0.9)	NS	0.6 (0.2–2.2)
Smoking								
Non-smokers		1.0		1.0		1.0		1.0
Smokers	0.09	4.3 (0.79–23.37)	NS	2.5 (0.62–10.38)	0.001	12.0 (2.9–49.6)	0.06	3.5 (0.9–13.1)
Residence								
Large city		1.0		1.0		1.0		1.0
Small city		1.0		1.0		1.0		1.0
Rural	NS†	0.6 (0.06–5.61)	NS†	1.3 (0.42–4.23)	NS†	1.0 (0.3–3.8)	NS†	1.5 (0.4–6.3)
	NS‡	0.2 (0.02–1.63)	NS‡	1.0 (0.33–3.02)	NS‡	1.0 (0.3–2.9)	NS‡	1.5 (0.5–4.4)
Atopic status§								
Non-atopics		1.0		1.0		1.0		1.0
Atopics	0.09	2.6 (0.8–8.1)	0.006	3.4 (1.4–8.11)	NS	0.5 (0.1–1.6)	NS	1.5 (0.5–4.8)

Data are expressed as percentage of responders or mean $\pm$ SD. OR, odds ratio; NS, not significant. *Current wheezing on a questionnaire and bronchial hyper-responsiveness to methacholine. †P-value versus large city. ‡P-value versus small city. §Skin test responses to one or more common aeroallergens.

The relationship between the prevalence of current asthma and risk factors was evaluated by multivariate analysis, as shown in Table 5. For adults younger than 39 and older than 65, asthma prevalence was not significantly associated with age, sex, smoking status, place of residence, percentage predictive value of FEV₁ and atopic status. In the 40–54 age group, asthma prevalence was negatively associated with percentage predictive value of FEV₁ ($P=0.04$), lower in males than in females (OR = 0.22, 95% CI 0.05–0.96, $P=0.04$), and higher in atopics than in non-atopics (OR = 3.38, 95% CI 1.4–8.11, $P=0.006$). However, in the 40–54 age group, asthma prevalence was independent of age, smoking status and place of residence. Among those aged 55–64, asthma prevalence was negatively associated with percentage predictive value of FEV₁ ($P<0.001$), lower in males than in females (OR = 0.232, 95% CI 0.05–0.9, $P=0.04$) and higher in active smokers than in non-smokers (OR = 12.0, 95% CI 2.9–49.6, $P=0.001$). The prevalence, however, was the same according to age, place of residence and atopic status.

Risk factors for spirometric lung function (Table 6)

Multivariate linear regression analysis was performed to evaluate the relationship between spirometric lung function (% predictive value of FEV₁) and the risk factors. Lung function decreased with increasing subject age ($P=0.001$), but increased with active smoking ($P=0.048$). It decreased with female gender ($P<0.001$), a rural residence ($P<0.001$) and in those with current asthma ($P<0.001$). However, lung function was not associated with atopic status.

Table 6. Multivariate analysis of relationships between baseline spirometric lung function and risk factors

Risk factors	FEV ₁ , % pred.	P
Age, years		0.001
≤ 39	96.8 $\pm$ 14.5	
40–54	94.6 $\pm$ 16.8	
55–64	92.8 $\pm$ 17.3	
≥ 65	87.5 $\pm$ 18.7	
Sex		< 0.001
Female	89.9 $\pm$ 13.6	
Male	98.4 $\pm$ 18.0	
Smoking		0.05
Non-smokers	91.9 $\pm$ 14.9	
Smokers	97.8 $\pm$ 18.0	
Residence		< 0.001
Large city	96.0 $\pm$ 15.7	
Small city	96.0 $\pm$ 17.7	
Rural	90.4 $\pm$ 15.6	
Atopic status*		0.48
Non-atopics	94.1 $\pm$ 16.8	
Atopics	94.9 $\pm$ 15.7	
Current asthma†		< 0.001
Non-asthmatics	95.7 $\pm$ 15.6	
Asthmatics	85.7 $\pm$ 17.8	

Data are expressed as mean $\pm$ SD. *Skin test responses to one or more common aeroallergens. †Current wheezing on a questionnaire and bronchial hyper-responsiveness to methacholine.

Discussion

Several standardized questionnaires, including the ISAAC questionnaire, the European Community Respiratory Health Survey (ECRHS) questionnaire and the International Union Against Tuberculosis and Lung Disease (IUATLD) Bronchial Symptoms Questionnaire, have been developed to assess the presence of symptoms suggestive of asthma [10, 12]. These questionnaires inquire about symptoms, such as wheezing, breathlessness and coughing, all of which are important features of asthma, but none of which are sufficiently specific to clinically diagnose the disease [13, 14]. The measurement of bronchial responsiveness has the potential to provide an objective measure of asthma prevalence, but BHR is only a component of the asthma phenotype and many people with BHR never experience asthma attacks or symptoms [4, 5]. In the present study, the estimate of asthma prevalence was based on the clinical diagnosis of asthma, and was satisfied when a subject had experienced wheezing during the previous 12 months, as reported on the questionnaire, and had exhibited BHR to methacholine. The evaluation of asthma prevalence in adults is complicated by the incidence of COPD and the difficulty of diagnostically separating these two conditions. To avoid the misclassification of pure COPD as asthma, subjects who registered a FEV₁ lower than either 1200 mL or 50% of the predictive value were excluded from the present study.

While risk factors that determine the development and persistence of asthma symptoms during childhood have been relatively well researched, very few studies have examined the prevalence and risk factors for the development of asthma during adulthood. The incidence and period of asthma prevalence is higher in children than adults [6, 15], and prevalence determined from cross-sectional data depends on both the incidence and the duration of the disease from its onset. In this instance, duration reflects both the degree to which asthma tends to persist or remit, and the mortality associated with the disease. Remission from asthma may occur, but it is unlikely after the age of 30, and the number of people who die of asthma is relatively small [7]. The present study demonstrates that the prevalence of current asthma is markedly higher among adults over 55 than among those under 55, suggesting that asthma incidence increases in the elderly.

The severity of wheezing in childhood is known to be associated with atopy, and is also associated with the persistence of wheezing and BHR in later childhood [8, 16]. However, the relationship between atopy and the incidence of asthma in adulthood remains controversial. The present study shows that atopy is associated with the prevalence of current asthma among adults aged 40–54, although this association was not observed between these two phenotypes among those under 40 and those aged 55 and over. This finding suggests that atopy is one of the risk factors for the development of asthma during adulthood.

In childhood, boys experience more wheezing [17], a higher incidence of diagnosed asthma [18] and more severe asthma [19] than girls. Around puberty, the differences in asthma incidence between girls and boys become less marked [6, 20]. During adulthood, it has been reported that women have a higher prevalence of symptoms, more bronchial responsiveness [21] and greater health service utilization [21]. The present study

demonstrates that female gender is positively associated with the prevalence of current asthma, and negatively with lung function, and that bronchial responsiveness to methacholine is similar in females and males. There is growing interest in elucidating gender differences in asthma prevalence. The hormonal status of women is believed to be likely to influence the manifestation of the disease. Some women experience severe exacerbations of asthma pre-menstrually, and a survey of women attending hospital departments for asthma treatment showed that significantly more were pre-menstrual than might be anticipated in the absence of a correlation [22, 23]. These findings suggest that female hormones are risk factors for the development of asthma symptoms during adulthood, and affect spirometric lung function.

The effect of asthma on the decline of lung function has been investigated, and asthmatics appear to eventually develop an irreversible airflow obstruction [24, 25]. The present study also found that percentage predictive value of FEV₁ was significantly lower in asthmatics than in non-asthmatics, and that BHR and asthma prevalence are negatively associated with percentage predictive value of FEV₁. This finding suggests that spirometric lung function declines more so with advancing age in asthmatics than in non-asthmatics, and that this decline is a risk factor for the development of asthma.

Active cigarette smoking causes serious adverse effects on the respiratory tract but there is little evidence that adult smokers experience any substantially increased risk of developing asthma [26]. Moreover, substantial data have been published showing that active smoking has the general effect of increasing non-specific bronchial responsiveness and irreversible airway obstruction [27], and increasing BHR associated with smoking does not reverse upon quitting smoking [28]. The present study demonstrates that BHR is positively associated with active smoking, especially current smoking, and that asthma prevalence is positively associated with active smoking, irrespective of current smoking, although baseline obstructive lung function was positively associated with active smoking. This effect of smoking upon the expression of BHR and current asthma was remarkable only among the elderly. Taken together, these findings suggest that active cigarette smoking is indeed a risk factor for the development of asthma, due to its effect upon the manifestation of asthma symptoms, and that it induces BHR in the elderly, as shown in Fig. 2.

In conclusion, the prevalence of current asthma is common among the elderly, and active smoking may play an important

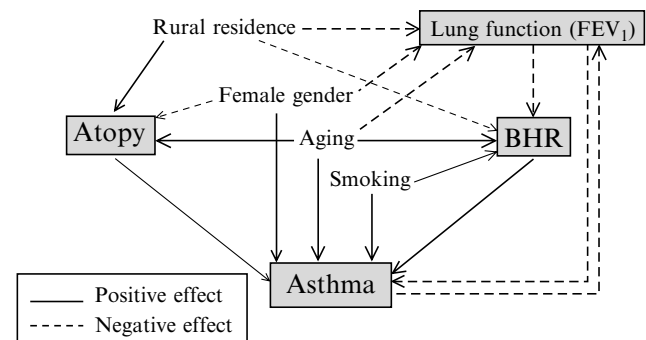


Fig. 2. Proposed relationship between current asthma and the risk factors.

role in the development of asthma and bronchial hyper-responsiveness in the elderly.

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