

Factors associated with allergen sensitizations in patients with asthma and/or rhinitis in China

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ABSTRACT

Background: Allergen sensitization is influenced by genetic and environmental factors; however, the factors related to sensitizations in patients with rhinitis and asthma in China are largely unknown. This study investigated the factors associated with allergen sensitizations in patients with asthma and rhinitis in China.

Methods: A cross-sectional survey was performed in 6304 patients with asthma and/or rhinitis from four regions of China. Patients completed a standardized questionnaire related to respiratory and allergic symptoms, family history of allergic diseases, smoking history, environmental exposure, and eating behaviors. They underwent skin-prick tests (SPTs) with 13 common aeroallergens. Blood samples were collected from 2268 of patients for specific IgE (sIgE) measurements against 16 common aeroallergens.

Results: Patients with both asthma and rhinitis had higher prevalence of SPT and sIgE positivity to most allergens than those with asthma or rhinitis alone ($p < 0.0001$). Male gender, family history of allergic rhinitis, air-conditioner usage, sleeping on a mattress, and frequently eating meat were associated with increased risk of SPT and sIgE positivity. Using air-conditioner and sleeping on a mattress were further found to be associated with sIgE positivity to mites and molds. However, increased age and fish, fruit, and raw vegetable intake decreased the risk of SPT and sIgE positivity.

Conclusion: Family history of allergic rhinitis, male gender, using an air conditioner, sleeping on a mattress, and frequent meat consumption are risk factors for allergen sensitizations, whereas increased age and frequent fish, fruit, and raw vegetable consumption may protect patients with asthma and/or rhinitis from developing sensitizations in China.

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The prevalence of respiratory allergy has increased in China^{1,2} as in many other countries worldwide^{3,4} over recent decades. Diseases with substantial increases in prevalence over short periods of time are likely to be influenced by lifestyle or environmental factors. The presence of atopic sensitization is a risk factor for the development of upper and lower respiratory symptoms.^{5,6} Exposure to sensitized allergens may exacerbate the symptoms of rhinitis and asthma by promoting airway inflammation, airflow limitation, and airway hyperresponsiveness. We recently performed an epidemiology study on the prevalence of sensitization in patients with asthma and/or rhinitis in mainland China.⁷ We found that the indoor allergens from house-dust mites (HDMs) were the antigens most consistently associated with the presence and severity of asthma, whereas outdoor weed pollen allergens from *Artemisia vulgaris* and *Ambrosia artemisiifolia* were associated with the development and severity of rhinitis.⁸

Atopic status of rhinitis and asthma is multifactorial, brought about by various family, genetic, and environmental influences. Some of the factors currently under investigation for increased risk of atopic diseases include genetic atopic predisposition,⁹ early childhood allergen exposure and sensitization,¹⁰ smoking and secondhand smoking,¹¹

and raising pets at home,¹² whereas children raised on a farm,¹³ attendance at day care at early ages,¹⁴ presence of siblings,¹⁵ and healthy diet¹⁶ appear to protect against the development of asthma and allergy.

The risk and protective factors for the development of atopy may vary from country to country. In fact, countries such as China, undergoing rapid changes toward “western” lifestyle, would concomitantly experience differences in the pattern of sensitization to allergens according to tremendous changes in environmental factors. Therefore, the aim of this study was to investigate the family history and environmental and exposure factors as well as eating habits in association with allergen sensitization in Chinese patients with asthma and/or rhinitis based on a recently completed epidemiology study.

METHODS

Study Design

This cross-sectional study was conducted from February 2006 to March 2007 in 17 cities with 24 centers from northern, eastern, south-western, and southern coastal regions of China (Table 1). All authors contributed equally to this study. Each center obtained approval of the study from their respective Institutional Review Board or Ethics Committee, and written informed consent was obtained from all study subjects. The Institutional Review Board of State Key Laboratory of Respiratory Disease approved the standardized protocol. Patients were aged 5–65 years attending outpatient clinics at 24 centers and were diagnosed with asthma alone, rhinitis alone, or asthma accompanied with rhinitis by evaluating their history, questionnaire, and relevant tests. The patients were invited in form of first-come first and gave written consent before the study. Rhinitis was defined as having symptoms of sneezing or a running, itchy, or blocked nose when the patient did not have a cold or flu. Asthma was defined by a history of recurrent dyspnea, wheezing or cough episodes, positive airway reversibility testing (forced expiratory volume in 1 second

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Table 1 Demographic characteristics of the study subjects (%)

	North <i>n</i> = 2333	East <i>n</i> = 1251	Western south <i>n</i> = 1516	Southern coast <i>n</i> = 1204	All regions <i>n</i> = 6304	χ^2	<i>p</i> Value
Cities	Beijing, Shenyang, Shijiazhuang, Taiyuan, and Jilin	Shanghai, Nanjing, Hangzhou, and Suzhou	Changsha, Wuhan, Chongqing, and Chengdu	Guangzhou, Xiamen, Nanning, and Haikou			
Age (yr)							
Children	43.4	58.5	55.8	47.7	49.8	1.41	0.70
Adult	56.6	41.5	44.2	52.3	50.2		
Gender							
Male	49.4	54.0	58.0	52.1	51.8	4.58	0.16
Female	50.6	46.0	42.0	47.9	48.2		
Diagnosis							
AS	30.4	36.6	32.0	31.7	38.2	5.09	0.09
RH	41.0	25.8	36.2	34.4	30.0		
AS+RH	28.6	37.6	31.8	33.9	31.8		

AS = asthma; RH = rhinitis; AS + RH = asthma with rhinitis.

increasing $\geq 12\%$ and 200 mL after inhalation of 400 mg of salbutamol), or positive airway responsiveness testing (forced expiratory volume in 1 second decreasing $\geq 20\%$ when $\leq 7.8 \mu\text{mol}$ of cumulative dose of histamine is administered).

All questionnaire interviewers and performers of skin-prick tests (SPTs) were trained before the study. Results of questionnaires and SPTs were sent every month to State Key Laboratory of Respiratory Disease, where the data were entered and analyzed. Quality control reports were then prepared for each center. Each completed questionnaire and skin test report was verified by the center supervisor and the results were double-checked by the principal investigator and fed back to each center. All questionnaire and skin test data were coded and entered into a programmed database by two persons independently. The entered data were checked for out-of-range values and errors.

Questionnaire

The questionnaire used in the survey was adopted from the Chinese translated version¹⁷ of the questionnaire from International Study of Asthma and Allergies in Childhood phase II,¹⁸ and modifications were made according to the real situation of China. It was then administered by the physicians or research nurses face to face with questions on demographic characteristics; family history of allergic diseases; symptoms of rhinitis, wheezing, or coughing; eczema and burning or itchy eyes; smoking habits; environment exposure factors; pet ownership; and dietary habits. Questions about impact of allergic symptoms on daily activities, work or school, nighttime sleep, and use of medications for controlling the symptoms were also asked.

Skin-Prick Test

The sensitization to thirteen common aeroallergens was tested including *Dermatophagoides pteronyssinus*, *Dermatophagoides farinae*, *Blomia tropicalis*, dog, cat, *Periplaneta americana*, *Blattella germanica*, *A. vulgaris*, *A. artemisiifolia*, mixed grass and tree pollen, and mold mix I and IV. Allergen extracts and control solutions were obtained from ALK (Horsholm, Denmark). Histamine (10 mg/mL) and diluent were used as positive and negative controls. SPT was performed on the volar side of the forearm. The wheal reaction after 15 minutes was measured as the mean of the longest diameter and the length of the perpendicular line through its middle. A positive skin reaction was defined as a wheal size of ≥ 3 mm, after subtraction of the negative control. Skin index (SI) was calculated by the ratio of wheal diameter of each allergen to diameter of wheal induced by histamine and scaled by the following criteria: SI < 0.5, “+”; $0.5 \leq \text{SI} < 1.0$, “++”; $1.0 \leq \text{SI} < 2.0$, “+++”; SI ≥ 2.0 , “++++”.

Serum IgE Analysis

All of the 6304 patients were also asked to sign a consent form to provide blood for measurement of serum IgE. Among them, 2268 from four regions agreed. Ten milliliters of peripheral blood was taken from each subject in the form of first come, first serve, coagulated at room temperature, centrifuged, stored at -20°C , and sent to the central laboratory at Guangzhou. The specific IgE (sIgE) against *D. pteronyssinus*, *D. farinae*, *B. tropicalis*, cat, dog, *P. americana*, *B. germanica*, *Penicillium*, *Cladosporium*, *Fusarium*, *Alternaria alternata*, sycamore, willow, cottonwood, elm, grass pollen, *A. vulgaris*, and *A. artemisiifolia* was measured on the ADVIA Centaur immunoassay system (Bayer Health Care, LLC, Tarrytown New York). The analysis for sIgE was performed only on patients in whom the testing was done. It was defined as positive if the measurement was ≥ 0.35 kU/L.

Statistical Analysis

SPT positivity was defined as the presence of at least one positive skin reaction to any allergen tested and sIgE positivity was defined as the presence of at least one sIgE ≥ 0.35 kU/L to any allergen tested. Prevalence rates of SPT and sIgE positivity of patient group with asthma alone, rhinitis alone, and both rhinitis and asthma are presented. The differences of the prevalence rates between different groups were determined by chi-square tests.

Univariable logistic regression analyses were performed to study the associations between family history and environmental factors as well as eating habits and SPT and sIgE positivity. Each of the explanatory variables was included in a model together with sex, age group, and the disease group variable. The explanatory variables that were associated with the dependent variable (overall *p* value for the explanatory variable < 0.05) were considered potential risks or protective factors of SPT and sIgE positivity and were introduced into the stepwise multivariable model. The criteria for entering and removing a variable were probability of F to enter ≤ 0.05 and probability of F to remove ≥ 0.10 . The results are given with adjusted odds ratios (with CI₉₅).

All data was categorized and analyzed using the Statistical Package for the Social Sciences for Windows Release 13.0 (SPSS, Inc., Chicago, IL).

RESULTS

Allergen Positivity in Patients with Asthma, Rhinitis, and Asthma with Rhinitis

SPT and sIgE allergen positivities in patients with asthma, rhinitis, and asthma with rhinitis are shown in Tables 2 and 3. Prevalence of positivity against HDMs including *D. farinae*, *D. pteronyssinus*, and *B.*

Table 2 Prevalence (%) of skin-prick test positivity in patients with AS, RH, and AS + RH

	AS (n = 1778)		RH (n = 2524)		AS + RH (n = 2002)		χ^2	p Value
	n	%	n	%	n	%		
<i>Dermatophagoides pteronyssinus</i>	948	53.3	1319	52.3	1367	68.3	136.4	<0.0001
<i>Dermatophagoides farinae</i>	971	54.6	1361	53.9	1390	69.4	131.1	<0.0001
<i>Blomia tropicalis</i>	645	36.3	902	35.7	1019	50.9	126.4	<0.0001
Dog	204	11.5	290	11.5	389	19.4	71.6	<0.0001
Cat	189	10.6	170	6.7	290	14.5	72.9	<0.0001
<i>Periplaneta americana</i>	293	16.5	336	13.3	387	19.3	30.1	<0.0001
<i>Blattella germanica</i>	196	11.1	268	10.6	261	13.0	6.9	0.031
<i>Artemisia vulgaris</i>	108	6.1	377	14.9	225	11.2	82.0	<0.0001
<i>Ambrosia artemisiifolia</i>	55	3.1	233	9.2	121	6.0	65.7	<0.0001
¹ Mixed grass pollen#	53	3.0	80	3.2	88	4.4	7.0	0.030
² Mixed tree pollen#	37	2.1	48	1.9	56	2.8	4.4	0.113
³ Mixed mold §	128	7.2	96	3.8	171	8.5	46.3	<0.001
⁴ Mixed mold i.v. ¶	106	6.0	76	3.0	97	4.8	22.7	<0.001
One or more positivity	1162	65.4	1740	68.9	1641	82.0	149.6	<0.0001

#Mixed grass pollen: *Dactylis glomerata*, *Festuca pratensis*, *Lolium perenne*, *Phleum pratense*, and *Poa pratensis*.

#Mixed tree pollen: *Ulmus americana*, *Platanus acerifolia*, *Salix caprea*, and *Populus deltoids*.

§Mixed mould I: *Alternaria alternata*, *Cladosporium herbarum*, *Fusarium sp.*, and *Chaetomium globosum*.

¶Mixed mould IV: *Penicillium brevicompactum*, *Penicillium expansum*, *Penicillium notatum*, and *Penicillium roqueforti*.

AS = asthma; RH = rhinitis; AS + RH = asthma with rhinitis.

Table 3 Prevalence (%) of specific IgE positivity in patients with AS, RH, and AS + RH

	AS (n = 773)		RH (n = 806)		AS+RH (n = 689)		χ^2	p Value
	n	%	n	%	n	%		
<i>Dermatophagoides pteronyssinus</i>	380	49.1	312	38.7	391	56.7	54.3	<0.0001
<i>Dermatophagoides farinae</i>	366	47.3	305	37.8	382	55.4	50.8	<0.0001
<i>Blomia tropicalis</i>	233	30.1	206	25.5	288	41.8	44.4	<0.0001
Dog	15	1.9	22	2.7	38	5.5	16.2	<0.0001
Cat	49	6.4	43	5.3	89	12.9	33.7	<0.0001
<i>Periplaneta americana</i>	16	2.1	7	0.9	8	1.2	3.0	0.232
<i>Blattella germanica</i>	22	2.8	17	2.1	15	2.2	1.0	0.618
<i>Artemisia vulgaris</i>	22	2.8	93	11.5	58	8.4	32.8	<0.0001
<i>Ambrosia artemisiifolia</i>	4	0.5	20	2.5	13	1.9	7.7	0.020
<i>Penicillium</i>	13	1.7	6	0.7	7	1.0	2.7	0.273
<i>Cladosporium</i>	0	0.0	0	0.0	1	0.1	3.0	0.347
<i>Alternaria alternata</i>	178	23.0	161	20.0	182	26.4	7.0	0.030
Sycamore	15	1.9	17	2.1	25	3.6	5.1	0.078
Willow	16	2.1	18	2.2	26	3.8	5.3	0.071
Cottonwood	18	2.3	18	2.2	31	4.5	8.3	0.015
Elm	16	2.1	32	4.0	34	4.9	7.6	0.022
Grass pollen	9	1.2	10	1.2	20	2.9	7.6	0.022
One or more positivity	583	75.4	576	71.5	559	81.1	19.6	<0.0001

AS = asthma; RH = rhinitis; AS + RH = asthma with rhinitis.

tropicalis is the highest among all tested allergens in both SPT and sIgE results. Patients with both asthma and rhinitis had more increased positive rates to HDMs, dogs, and cats than with asthma or rhinitis alone ($p < 0.0001$). Prevalence of positivity to *A. vulgaris* and *A. artemisiifolia* was increased in patients with rhinitis ($p < 0.0001$). Approximately 13.3–19.3% and 10.6–13.0% of patients had SPT positivity, whereas only 0.9–2.1% and 2.1–2.8% of patients had sIgE positivity to *P. americana* and *B. germanica*. When compared with patients with asthma or rhinitis alone, patients with both asthma and rhinitis had significantly higher prevalence rates of SPT and sIgE positivity to more than one allergen ($p < 0.0001$).

Factors Associated with SPT and sIgE Positivity of Asthma and Rhinitis

The evaluation in “univariate” analysis of each of the explanatory variables is presented in Table 4. It showed that male gender, family history of allergic rhinitis, using an air conditioner, and consuming meat were significantly associated with SPT positivity and sIgE positivity in all patients. Sleeping on a mattress was associated with SPT and sIgE positivity in patients with both asthma and rhinitis. Drinking fruit juice was found to have an association with sIgE positivity in patients with rhinitis.

Table 4 Univariate analysis of potential risk or protective factors for skin and specific IgE sensitizations in patients with AS, RH, and AS+RH

Explanatory Variable	Dependent Variable					
	Skin-Prick Test Positivity Odds Ratio# (95% CI)			Specific IgE Positivity Odds Ratio# (95% CI)		
	AS <i>n</i> = 1778	RH <i>n</i> = 2524	AS + RH <i>n</i> = 2002	AS <i>n</i> = 773	RH <i>n</i> = 806	AS + RH <i>n</i> = 689
Gender						
Female	1	1	1	1	1	1
Male	1.88 (1.53–2.32)§	1.14 (0.96–1.36)§	1.17 (0.92–1.50)§	1.96 (1.56–2.63)#	1.24 (1.06–1.78)#	2.09 (1.60–3.30)§
Age (yr)						
5–14	1	1	1	1	1	1
15–24	1.12 (0.71–1.76)	1.03 (0.78–1.37)	0.80 (0.49–1.28)	0.12 (0.07–0.44)	0.27 (0.13–0.52)§	0.16 (0.08–0.32)§
25–34	0.70 (0.48–1.02)	0.80 (0.62–1.04)	0.49 (0.33–0.73)§	0.09 (0.04–0.22)§	0.16 (0.08–0.27)§	0.08 (0.04–0.14)§
35–44	0.51 (0.38–0.69)§	0.45 (0.35–0.59)§	0.27 (0.19–0.38)§	0.06 (0.03–0.13)§	0.17 (0.09–0.30)§	0.07 (0.04–0.13)§
45–54	0.44 (0.31–0.63)§	0.34 (0.25–0.46)§	0.24 (0.17–0.39)§	0.06 (0.03–0.12)§	0.10 (0.05–0.19)§	0.06 (0.03–0.11)§
55–65	0.33 (0.22–0.50)§	0.26 (0.17–0.41)§	0.31 (0.19–0.52)§	0.06 (0.02–0.16)§	0.12 (0.05–0.33)§	0.07 (0.03–0.15)§
Smoking history						
Never smoked	1	1	1	1	1	1
Self, present smoker	1.06 (0.67–1.70)	0.96 (0.50–1.27)	0.84 (0.51–1.40)	1.19 (0.40–3.51)	0.72 (0.38–1.36)	0.71 (0.31–1.60)
Self, ex-smoker	0.73 (0.48–1.12)	0.79 (0.49–1.08)	0.82 (0.53–1.26)	1.56 (0.57–4.30)	0.62 (0.31–1.24)	0.83 (0.63–1.18)
Second-hand smoker	1.02 (0.83–1.25)	1.21 (1.02–1.45)#	1.12 (0.89–1.42)	1.01 (0.61–1.68)	0.99 (0.68–1.42)	1.38 (0.96–1.99)
Family history of						
Allergic rhinitis	1.55 (1.19–2.02)§	1.60 (1.30–1.96)§	1.58 (1.21–2.06)§	2.68 (1.40–5.10)§	1.80 (1.23–2.61)§	1.85 (1.29–2.66)§
Asthma	1.05 (0.82–1.34)	1.09 (0.82–1.46)	1.16 (0.87–1.536)	1.34 (0.80–2.23)	1.20 (0.72–2.10)	1.32 (0.90–1.93)
Food allergy	1.16 (0.77–1.79)	1.03 (0.67–1.59)	1.26 (0.73–2.18)	0.80 (0.35–1.85)	1.13 (0.54–2.33)	1.48 (0.77–2.85)
Allergic dermatitis	1.42 (1.04–1.95)#	0.99 (0.73–1.34)	1.46 (1.01–2.11)#	1.46 (0.92–2.32)	1.04 (0.63–1.73)	3.81 (1.49–9.77)§
Raising cat at home	1.29 (0.87–1.90)	0.76 (0.52–1.09)	0.83 (0.53–1.30)	0.74 (0.39–1.43)	0.77 (0.36–1.66)	1.01 (0.53–1.95)
Raising dog at home	1.09 (0.78–1.54)	0.84 (0.62–1.12)	0.95 (0.66–1.38)	0.40 (0.23–0.72)§	0.76 (0.45–1.26)	0.66 (0.42–1.06)
Pets in bedroom	1.10 (0.80–1.51)	1.33 (0.98–1.82)#	1.47 (0.99–2.18)#	0.74 (0.40–1.37)	0.87 (0.50–1.51)	1.55 (1.35–1.88)#
Sleep with mattress	1.05 (0.82–1.36)	1.12 (0.88–1.42)	1.37 (1.01–1.84)#	0.93 (0.55–1.59)	1.90 (1.04–3.05)#	1.96 (1.17–4.03)#
Using air conditioner	1.42 (1.19–1.69)§	1.29 (1.03–1.62)#	1.65 (1.28–2.13)§	1.84 (1.28–2.64)§	1.54 (0.93–2.55)	1.57 (1.08–2.30)#
Resident building (yr)						
<10	1	1	1	1	1	1
≥10 and <30	0.79 (0.57–1.09)	1.03 (0.76–1.39)	0.83 (0.53–1.32)	1.18 (0.54–2.57)	0.74 (0.55–1.18)	1.18 (0.54–2.57)
≥30	1.10 (0.83–1.46)	1.17 (0.89–1.55)	1.04 (0.71–1.53)	1.26 (0.89–3.84)	1.86 (1.21–4.91)#	2.60 (1.19–5.84)§
Resident level in the building						
≥9 floor	1	1	1	1	1	1
≥3 and <9 floor	1.04 (0.79–1.35)	1.43 (1.14–1.77)#	1.05 (0.67–1.24)	1.04 (0.53–2.03)	0.88 (0.54–1.42)	1.16 (0.70–1.91)
<3 floor	1.03 (0.86–1.44)	1.21 (0.78–1.41)	0.97 (0.59–1.27)	1.16 (0.84–2.89)	0.99 (0.40–2.47)	1.95 (1.28–4.51)§
Eating habits (two or more meals per day)						
Meat	1.65 (1.35–2.02)§	1.44 (1.21–1.71)§	1.81 (1.42–2.31)§	1.53 (0.99–2.35)#	1.07 (0.74–1.55)	1.33 (1.19–2.22)#
Fish	0.11 (0.56–1.06)	1.13 (0.83–1.53)	0.66 (0.46–0.95)#	0.46 (0.21–0.99)§	1.08 (0.63–1.86)	0.82 (0.45–1.52)
Fruits	0.74 (0.43–0.94)#	0.88 (0.49–0.90)#	0.65 (0.33–0.74)§	1.10 (0.84–1.34)	0.94 (0.65–1.01)#	0.65 (0.35–0.74)§
Raw vegetable	0.83 (0.66–1.01)#	0.76 (0.59–0.97)#	0.66 (0.58–0.91)#	0.77 (0.41–0.94)#	0.72 (0.47–1.09)	0.62 (0.33–0.86)§
Cooked vegetable	0.74 (0.57–0.95)#	0.87 (0.70–1.10)	0.73 (0.54–1.01)#	0.50 (0.20–1.23)	0.71 (0.40–1.26)	0.98 (0.52–1.83)
Fruit juice	1.29 (0.83–2.03)	0.75 (0.48–1.15)	1.29 (0.76–2.17)	0.81 (0.23–2.87)	2.10 (0.91–4.88)#	1.67 (0.74–3.80)
Fizzy drink	1.17 (0.60–2.29)	1.27 (0.80–2.01)	0.75 (0.41–1.34)	1.84 (0.30–2.22)	1.47 (0.45–4.79)	0.51 (0.20–1.29)

#Odds ratio adjusted for group, region, gender, and age group in a logistic regression model.

#*p* < 0.1; §*p* < 0.05.

AS = asthma; RH = rhinitis; AS + RH = asthma with rhinitis.

We also found that older age and frequently consuming fruits and raw vegetable were significantly associated with reduction of the possibility of having SPT and sIgE positivity in most patients. Furthermore, eating fish was associated with decreasing the possibility of having SPT positivity in patients with both asthma and rhinitis, as well as sIgE positivity in patients with rhinitis.

The final models for both dependent variables obtained by stepwise regression analyses included family history of allergic rhinitis and dermatitis; raising a dog at home; pets in the bedroom; sleep-

ing on a mattress; use of an air conditioner; pillow with plant or herb material; and having meat, fish, fruits, and raw or cooked vegetable (two or more meals per day) adjusted for group, sex and age group. Table 5 shows the mutually adjusted odds ratio estimates for all variables selected in the final models. Male gender, having family history of allergic rhinitis, sleeping on a mattress, using an air conditioner, and having meat (two or more meals per day) were associated with the possibility of increased risk of sensitization in our patients. On the other hand, older age; raising

Table 5 Multivariate logistic regression analysis with selected variables for skin and specific IgE sensitizations in patients with AS, AR, and AS + RH

Explanatory Variable	Dependent Variable					
	Skin-Prick Test Positivity Odds Ratio* (95% CI)			Specific IgE Positivity Odds Ratio* (95% CI)		
	AS n = 1778	RH n = 2524	AS + RH n = 2002	AS n = 773	RH n = 806	AS + RH n = 689
Male (yr)	1.76 (1.42–2.06)§	1.06 (0.87–1.28)#	1.15 (0.89–1.48)§	1.89 (1.50–2.47)#	1.21 (1.00–1.56)#	2.00 (1.54–3.26)§
15–24	NS	NS	NS	NS	0.31 (0.23–0.55)§	0.14 (0.07–0.30)§
25–34	NS	NS	0.37 (0.25–0.81)§	0.10 (0.06–0.28)§	0.20 (0.09–0.25)§	0.07 (0.02–0.12)§
35–44	0.48 (0.36–0.66)§	0.36 (0.25–0.49)§	0.24 (0.17–0.36)§	0.07 (0.04–0.17)§	0.16 (0.08–0.29)§	0.06 (0.03–0.12)§
45–54	0.44 (0.31–0.63)§	0.34 (0.25–0.46)§	0.24 (0.17–0.39)§	0.06 (0.03–0.12)§	0.10 (0.05–0.19)§	0.06 (0.03–0.11)§
55–65	0.38 (0.24–0.52)§	0.28 (0.19–0.45)§	0.34 (0.21–0.57)§	0.05 (0.02–0.17)§	0.14 (0.05–0.38)§	0.09 (0.06–0.19)§
Family history of allergic rhinitis	1.73 (1.59–1.88)§	1.73 (1.61–1.87)§	1.66 (1.53–1.81)§	1.57 (1.33–1.97)#	1.69 (1.19–2.05)§	1.73 (1.53–2.00)#
Resident building ≥30 yr	NS	NS	NS	NS	NS	1.47 (1.12–2.36)#
Resident level <3 floor	NS	NS	NS	NS	NS	1.23 (1.08–3.13)#
Sleep with mattress	NS	NS	1.36 (1.01–1.84)#	NS	1.79 (1.16–3.23)#	2.07 (1.33–3.92)#
Using air conditioner	1.28 (1.07–1.53)§	NS	1.55 (1.19–2.00)§	2.34 (1.66–3.31)§	2.05 (1.26–3.34)§	1.89 (1.32–2.71)§
Having meat (two or more meals per day)	1.63 (1.33–1.99)§	1.35 (1.13–1.61)§	1.61 (1.28–2.05)§	2.02 (1.23–3.32)§	NS	1.56 (1.09–2.22)#
Having fish (two or more meals per day)	NS	NS	0.64 (0.44–0.92)#	0.37 (0.19–0.78)§	NS	NS
Having fruits (two or more meals per day)	NS	NS	0.75 (0.473–0.86)#	NS	NS	0.69 (0.39–0.80)#
Having raw vegetable (two or more meals per day)	0.76 (0.58–0.97)#	NS	NS	0.20 (0.08–0.46)§	NS	NS

#Odds ratio adjusted for group, region, gender, and age group in a logistic regression model.
 #p < 0.05; § p < 0.01.
 AS = asthma; RH = rhinitis; AS + RH = asthma with rhinitis; NS = not significant.

Table 6 The association between environmental variables and specific IgE positivity of mites and molds in patients with AS, AR, and AS + RH

Explanatory Variable	Dependent Variable					
	Specific IgE Positivity of Mite* Odds Ratio§ (95% CI)			Specific IgE Positivity of Mold# Odds Ratio§ (95% CI)		
	AS	RH	AS + RH	AS	RH	AS + RH
Sleep with mattress	NS	NS	1.36 (1.01–1.84)¶	NS	1.79 (1.16–3.23)¶	2.07 (1.33–3.92)¶
Using air conditioner	1.28 (1.07–1.53)¶	NS	1.55 (1.19–2.00)¶	2.34 (1.66–3.31)¶	2.05 (1.26–3.34)¶	1.89 (1.32–2.71)¶
Resident building ≥30 yr	NS	NS	1.26 (1.09–2.11)¶	NS	NS	1.82 (1.21–3.32)¶
Resident level <3 floor	NS	NS	1.66 (1.32–3.03)¶	NS	NS	1.53 (1.65–3.73)¶

*Any of Dermatophagoides pteronyssinus, Dermatophagoides farinae, or Blomia tropicalis specific IgE level of ≥0.35kU/L.
 #Any of Penicillium, Cladosporium, or Alternaria alternata specific IgE level of ≥0.35kU/L.
 §Odds ratio adjusted for group, region, gender, and age group in a logistic regression model.
 ¶p < 0.05; ¶¶p < 0.01.
 AS = asthma; RH = rhinitis; AS + RH = asthma with rhinitis; NS = not significant.

dogs at home; using a pillow with plant or herb materials; and having fish, fruits, and raw vegetables (two or more meals per day) were associated with the possibility of reduced risk of sensitization.

The association between environmental variables and mite and mold sIgE positivity adjusted by sex and age group is reported separately for patients with various diagnoses (Table 6). It appears that there is a significant association of using an air conditioner, sleeping on a mattress, living in a building that is >30 years old and on the first and second floor with mite and mold sIgE positivity in patients with asthma and rhinitis ($p < 0.05$).

DISCUSSION

In this cross-sectional study we investigated the risk and protective factors in relation to SPT and serum sIgE positivity in patients with asthma and/or rhinitis in China. First, we found that HDMs are the most prevalent allergens in patients with asthma and/or rhinitis in both SPT and sIgE findings. Second, we found that men had a higher prevalence of sensitization than women. A positive family history of allergic rhinitis, sleeping on a mattress, using an air conditioner, and frequently consuming meat were associated with increased risk of sensitization, whereas being older

and frequently eating fish, fruit, and raw vegetables appeared to be protective against sensitization.

Factors that influenced the prevalence of allergic disease included a host and environmental factors of which mechanism are complex and interactive. A family history of an allergic condition is a recognized risk factor for the development of an allergic condition in an individual, particularly for allergic disorders such as asthma, eczema, and allergic rhinitis.¹⁹ In our study, in the final models of stepwise multivariate regression analyses, family history of allergic rhinitis was found to be associated with sensitization in our patients. However, it is not known whether this is because of an increased overall tendency toward sensitization or to the inheritance of specific allergen sensitization. There is accumulating evidence that both genetic and environmental factors play important roles in the etiology of allergic diseases. It is likely that there is a multilevel interaction between genetic and environmental factors.²⁰

We showed a significant association between air-conditioner usage and sleeping on a mattress and SPT and sIgE positivity in patients with asthma and rhinitis. Using an air conditioner and sleeping on a mattress were also found to be associated with sIgE positivity of mites and molds. This finding indicated that air conditioners and mattresses may be important sources of exposure to HDMs and mold in China. We performed a study on measuring levels of mite allergens from beds in Guangzhou where we found 88% of dust samples from mattresses showed levels of Der1 above 10 $\mu\text{g/g}$.²¹ Wu *et al.*²² collected dust from air-conditioner filters from six cities of China and found *D. pteronyssinus* and *D. farinae* in the filters. Cui and Wang performed a study in Huainan city of Anhui province of China and also suggested that mite occurrence rate on the surface of air-conditioner filters was high.²³ While the air conditioner is running, mite allergens accumulated in the dust of filters and the settled dust can be continuously whirled into indoor air and raise the allergy risk for patients with asthma and rhinitis living in the room. Lian *et al.*²⁴ had tested the concentration of major mite allergens (Der1 and Der 2) in indoor air of 60 families in Guangzhou city and observed a significant increase of allergen concentration after air-conditioner operation. Thus, exposure to mites in the dust from mattresses and air-conditioner filters may be an important risk for sensitizations in patients with asthma and rhinitis.

In line with our study, many studies in United States showed strong evidence that environmental exposures lead to asthma exacerbations and cause allergy and asthma. One study showed a higher prevalence of cockroach and mite allergens among households in New York City and cockroach and dust-mite allergen exposure has been causally linked with the development of allergy and asthma in susceptible children in this area.²⁵ In 2002–2003, The New York State Department of Health conducted the National Asthma Survey and found statistically significant positive associations between current asthma and the presence of mold, air cleaners, dehumidifiers, and humidifiers.²⁶ Therefore, public health interventions around the world should focus on educating households about potential allergy and asthma triggers and their sources and teach methods to prevent, reduce, or eliminate them.

Similarly, with other studies,^{27,28} we also found that allergen sensitization in patients with asthma and/or rhinitis, measured by either SPT or sIgE, decreased with the increase of age. The prevalence of sensitization was significantly higher in men than in women in most of the age groups. Arbes *et al.* also indicated in the third National Health and Nutrition Examination Surveys in the United States that male subjects were more likely than female subjects to have positive test responses to allergens.²⁹ The mechanisms of these findings are not entirely clear. Further research is necessary to unveil the mechanisms related to the decrease of sensitization in elderly patients and difference in gender.

In this study, we found frequent consumption of meat to be related to a higher risk of sensitization whereas fish and vegetable intake was associated with a protection of SPT or sIgE positivity. Meats, espe-

cially red meat from animals, are dietary sources of trans fatty acids. There is some evidence that dietary intake of trans fatty acids is associated with asthma and atopy.³⁰ Fish is rich in n-3 poly unsaturated fatty acids, which have been shown to counter-balance pro-allergic T-helper 2 activity.³¹ Our result of a protective association of fish consumption with sensitization agrees with many other studies.^{32–34} Vegetables and fruits contain antioxidants and other biologically active factors, which may contribute to the protective effect in atopy.³⁵ In clinical studies, dietary vitamin C and E intake has been shown to be inversely associated with plasma IgE levels.^{36,37}

We realized that prevalence rate of SPT positivity to *P. americana* and *B. germanica* was 10-fold higher than that of sIgE positivity in our patients; however, we also found that within the cockroach SPT⁺ patients, 88% were also found to have a positive SPT reaction against *D. pteronyssinus*. Using skin index levels in comparison with the *D. pteronyssinus* and *P. americana* and *B. germanica*, the cockroach SPT levels were, in general, much lower (data not shown). The higher positive rate of cockroach SPT results could be caused by false positive SPT reactions against *D. pteronyssinus* and/or cockroaches. The importance of cockroaches as a risk factor for sensitization and triggers of allergic symptoms in China needs to be further investigated by correlating serological measurements with clinical manifestations of cockroach allergy.

In conclusion, this study suggests that having family history of allergic rhinitis, male gender, using an air conditioner, and sleeping on a mattress as well as frequent meat consumption are risk factors for allergen sensitizations, whereas older age and consumption of fish, fruit, and vegetables may prevent patients with asthma and/or rhinitis from having sensitization.

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