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SUPPORTING INFORMATION

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Prevalence and risk factors for allergic rhinitis in adults and children living in different grassland regions of Inner Mongolia

To the Editor,

Allergic rhinitis (AR) is a growing concern throughout the world. Over 500 million people around the world have AR, and its prevalence has increased over the past few decades.^{1,2} In China, the prevalence of self-reported AR in 18 major cities was found to be 17.6% in adults³ and 9.8% in children.⁴ We have recently demonstrated that the prevalence of pollen-induced AR in the Inner Mongolia grassland area, a part of Eurasian steppe in North of China,⁵ was 18.5% and that this was influenced by local environmental and climate conditions.⁶ In the present study, we aimed to compare physician-diagnosed AR (ie, self-diagnosed AR confirmed with (+) SPT by physician) and associated clinical symptoms, comorbidities, and risk factors in children and adult populations from six regions (Tongliao, Jarud Banner, Kailu County, Xilinhot, Erenhot, and Duolun) in the Xilingol and Horqin grasslands in Inner Mongolia, with geographical coordinates 111°17'E to 122°57'E and 41°45'N and 45°50'N, and covering an area 262 130 km² in total (Figure 1).

This was a population-based cross-sectional survey that was conducted using a standard multistage, stratified, clustered, and randomized sampling design. The study was carried out from May to August 2015 in two phases. In the first phase, a questionnaire to collect demographic, clinical, and socioeconomic data (Figure S1) was completed during a face-to-face interview by fieldworkers with the inhabitants who had provided written informed consent for themselves or their children to participate in the study in the six study areas. In the second phase, all subjects who had completed the questionnaire were invited to undergo skin prick tests (SPTs) by medical specialists. Details of the selection criteria and stratification of the subjects, diagnosis of allergic disease (AR, asthma, and conjunctivitis), and the materials and methods used in this study are shown in the methods section in this article's Appendix S1 at onlinelibrary.wiley.com/journal/13989995. The research protocol was approved by the ethics committees of hospitals in Inner Mongolia and Beijing Shijitan Hospital (Ethic committee vote number (2015) Ethics Quick Trial No. 3).

A total of 6200 inhabitants were recruited, of whom 6043 (97.5%) including 3600 adults (59.6%; aged 18-79 years) and 2443 children (40.4%; aged 0-17 years) (Table S1), completed the questionnaire, and underwent SPTs. The overall prevalence of self-reported AR and

physician-diagnosed AR was found to be 32.4% (1958/6043) and 18.8% (1134/6043), respectively. The prevalence of self-reported AR and physician-diagnosed AR in adults was 36.3% (1308/3600) and 21.8% (783/3600), respectively, and in children was 26.6% (650/2443) and 14.4% (351/2443), respectively. The prevalence of physician-diagnosed AR in adults and children tended to be significantly higher in urban areas than in rural areas ($P < 0.0001$), with males more commonly affected than females among children ($P < 0.0231$) (Table S1). The prevalence of physician-diagnosed AR increased with age and peaked at age range 18-39 years old, before gradually decreasing to the lowest level in subjects aged above 60 years (Table S2; Figure S1). Furthermore, significant differences were noted in the percentage of subjects with physician-diagnosed AR between the six areas ($P < 0.0001$), possibly as a consequence of differences in vegetation and the geographical environment in the different areas. In subjects with physician-diagnosed AR, nasal discharge (86.2%) was more frequent than nasal congestion (77.0%) in adults, whereas nasal congestion (82.1%) was more frequent than nasal discharge (76.9%) in children. Overall, significantly greater number of adults with physician-diagnosed AR (53%-67%) suffered from eye symptoms, including itching, redness, and tearing, compared to children with physician-diagnosed AR (36%-57%; $P < 0.01$ for all symptoms) (Table S3). Non-rhinitis-associated symptoms such as fatigue and somnolence were also observed, which are mentioned in Table S3. Although drug-induced adverse reactions were excluded during the interview, it is unlikely that fatigue and somnolence were related to the intake of antihistamines for allergic rhinitis. While children with AR were more likely to have asthma compared with adults (19.7% vs 13.5%, $P = 0.0084$), adults with physician-diagnosed AR were more likely to have conjunctivitis than children (70.5% vs 61.5%, $P = 0.0029$).

Figure 2 shows the mean monthly pollen counts of nine pollens and the presence of physician-diagnosed AR symptoms over a period of 12 months in children and adults in the overall study region (Figure 2A) and the six individual areas investigated in the region (Figure 2B-G). The adults and children with physician-diagnosed AR experienced exacerbation of AR symptoms twice a year, which peaked in April, July, and August (Figure 2A). In some of the six individual areas, we found that despite the presence of high pollen

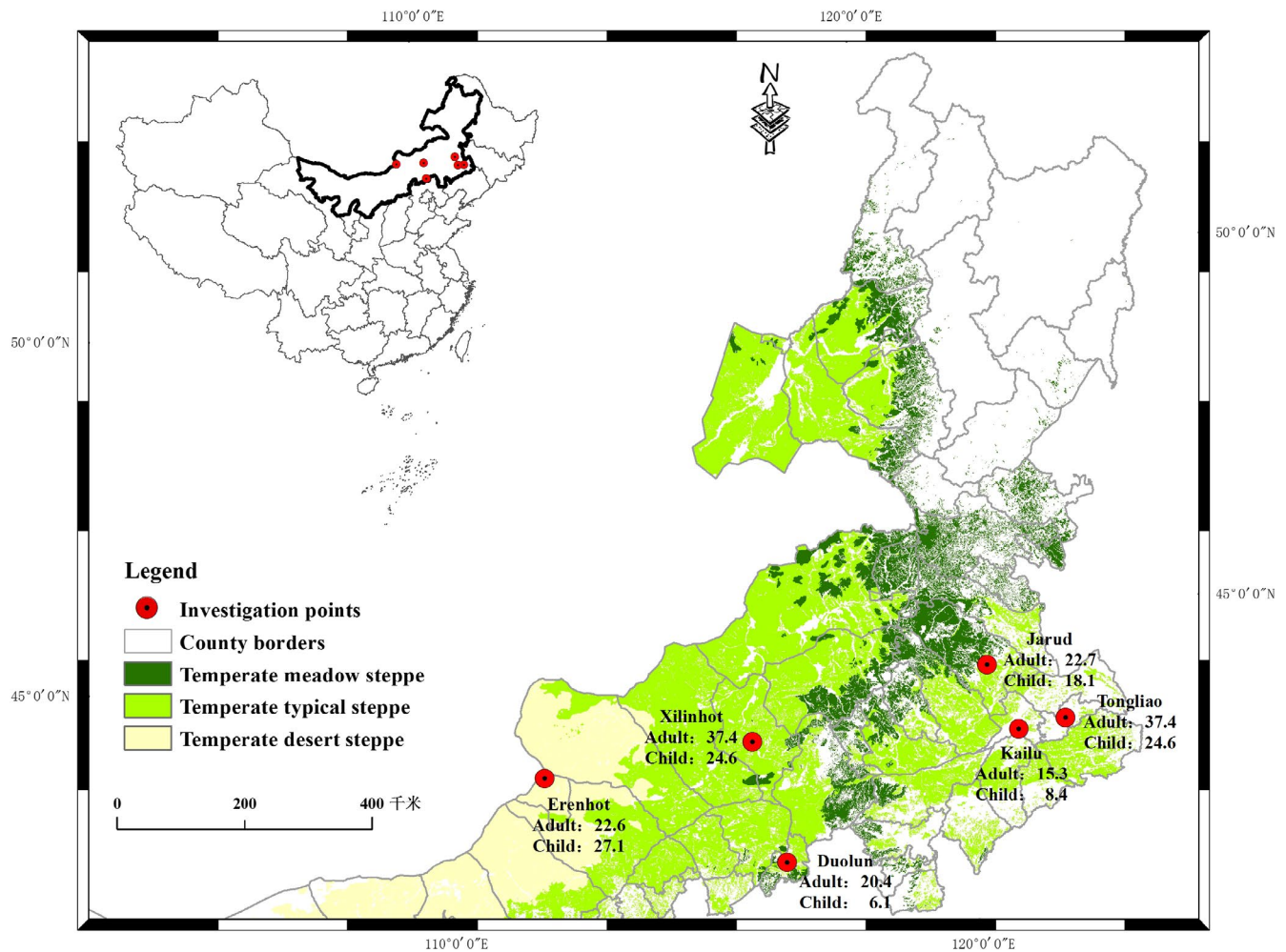


FIGURE 1 The locations of the six study areas in Inner Mongolia. The number given for each area represents the prevalence of physician-diagnosed allergic rhinitis in adults and children

counts, the incidence of symptoms of rhinitis was comparatively low (Figure 2C: Duolun, 2F: Kailu), whereas in other places despite the presence of low pollen counts, the incidence of symptoms of rhinitis was high (Figure 2D: Erenhot). The differences in incidence of symptoms may be due to the differences in climate in these three areas compared to other areas. While precipitation in Duolun and Kailu is relatively high, precipitation in the relatively dry semi-desert Erenhot area is low. Moreover, differences noted in the timing of the pollen season, the concentrations of pollen, as well as the combination of the two main pollens of *Artemisia* and *Chenopodium*, in the six regions may affect the prevalence of rhinitis and need to be investigated further. The top SPT-positive allergens were *Artemisia* species (Figure S2), with significant differences observed between children and adults with physician-diagnosed AR in the amount of positive SPTs (Figures S3 and S4). Children more frequently showed a

mono-sensitization pattern than adults ($P < 0.0001$), while adults more frequently showed a poly-sensitization pattern ($P < 0.0001$) (Figure S3).

The risk factors associated with physician-diagnosed AR in adults and children were evaluated using multivariate regression analyses (Table 1). In children with physician-diagnosed AR, the males were associated with a higher risk of AR, whereas in adults with physician-diagnosed AR, the waist circumference had a significantly positive correlation with the risk of AR (OR = 1.010, 95% CI: 1.002-1.019, $P = 0.0154$). In contrast, there was no correlation between AR and obesity, with no significant difference demonstrated even for AR prevalence among different levels of obesity in adults (Table S5). Family history was shown to increase the risk of AR in both adults (OR = 2.849, 95% CI: 2.392-3.393, $P < 0.0001$) and children (OR = 3.554, 95% CI: 2.726-4.635, $P < 0.0001$). Subjects with a

FIGURE 2 The mean total monthly pollen count and presence of physician-diagnosed AR symptoms during the 12 months of 2015. A, represents the overall data for the six study areas. B to G represents the data of the six individual areas. (B: Xilinhot; C: Duolun; D: Erenhot; E: Jarud; F: Kailu; G: Tongliao). Ar: *Artemisia*; Be: *Betula*; Ch: *Chenopodium*; Gr: *Gramineae*; Hu: *Humulus scandens*; Ju: *Juniperus chinensis* var. *chinensis*; Po: *Populus*; Sa: *Salix*; Ul: *Ulmus pumila*

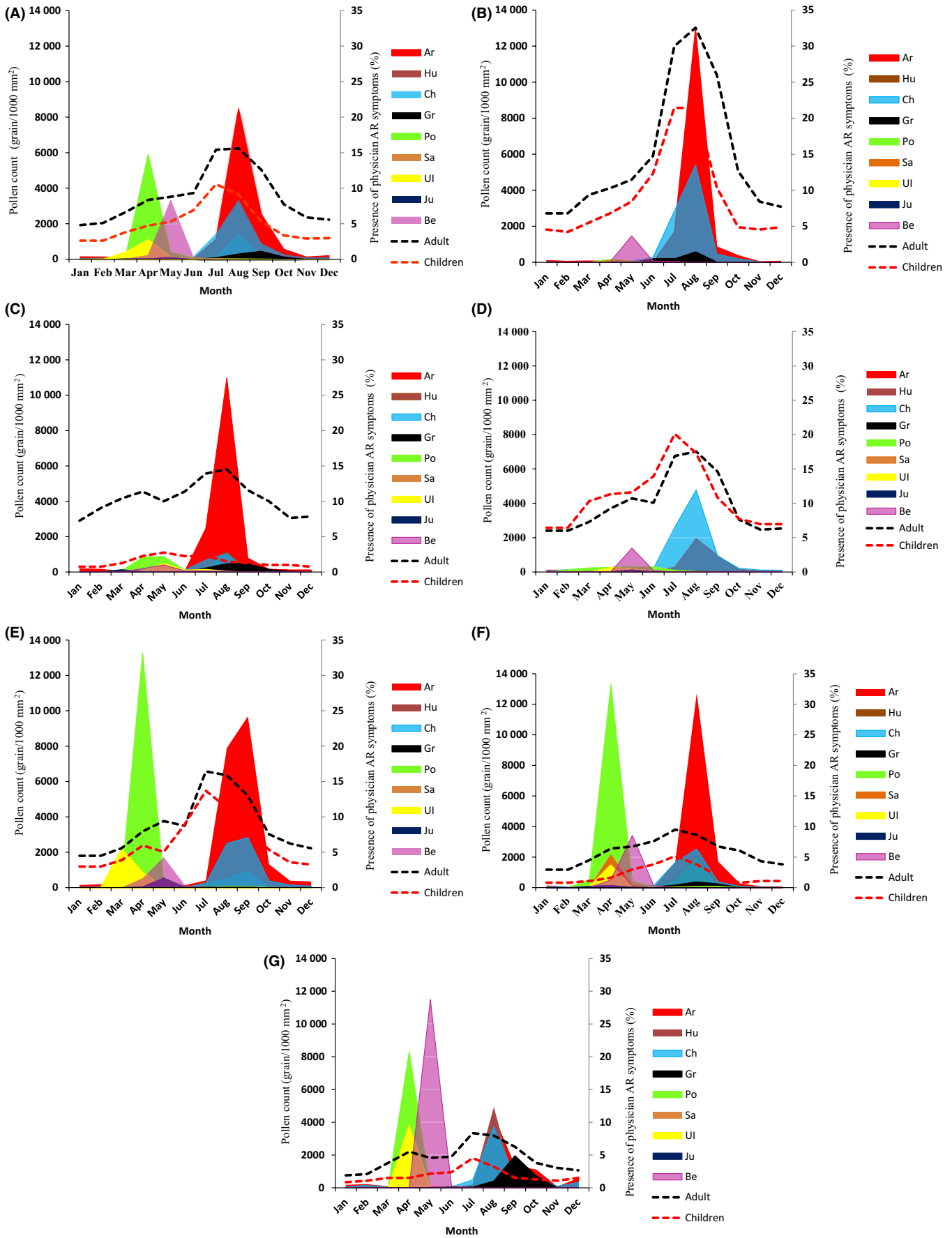


TABLE 1 The risk factors and OR (95% CI) among subjects with physician-diagnosed allergic rhinitis (AR) in adults and children

Characters	Physician-diagnosed AR in children		Physician-diagnosed AR in adults	
	OR (95% CI) _{adj} ^a	P value	OR (95% CI) _{adj} ^a	P value
Gender male (ref=female)	1.555 (1.215-1.992)	0.0005	1.061 (0.898-1.252)	0.4877
Age				
≤6	1.0		-	-
7-12	2.561 (1.873-3.501)	<0.0001	-	-
13-17	5.534 (3.947-7.759)	<0.0001	-	-
18-39	-	-	1.0	
40-59	-	-	0.505 (0.424-0.601)	<0.0001
≥60	-	-	0.235 (0.171-0.324)	<0.0001
Waist, cm	1.013 (0.999-1.026)	0.0601	1.010 (1.002-1.019)	0.0154
Body mass index, kg/m ²	0.994 (0.965-1.024)	0.6918	1.018 (0.997-1.04)	0.0948
Family history of AR				
No	1.0		1.0	
Yes	3.554 (2.726-4.635)	<0.0001	2.849 (2.392-3.393)	<0.0001
Type of feeding				
Breastfeeding only	1.0		-	-
Mixed type	1.472 (1.099-1.971)	0.0096	-	-
Smoking habit				
Never smoking	-	-	1.0	
Now smoking	-	-	0.845 (0.664-1.076)	0.1726
Ever smoking	-	-	1.308 (0.916-1.866)	0.1392
Type of heating				
Central heating	1.0		1.0	
Coal heating	0.505 (0.326-0.784)	0.0023	0.470 (0.342-0.646)	<0.0001
Wood heating	0.208 (0.102-0.427)	<0.0001	0.682 (0.494-0.942)	0.0200
Others	0.596 (0.345-1.03)	0.0636	0.995 (0.619-1.6)	0.9846
Antibiotic use (>3 times/year)				
No	1.0		1.0	
Yes	0.851 (0.592-1.224)	0.3852	1.357 (1.104-1.668)	0.0037
Outdoor activity (hours/day)				
<1 h	1.0		1.0	
1-2 h	0.810 (0.551-1.189)	0.2812	0.846 (0.66-1.084)	0.1856
2-3 h	0.803 (0.54-1.194)	0.2787	0.828 (0.632-1.085)	0.1715
3-4 h	0.620 (0.382-1.004)	0.0520	0.755 (0.546-1.042)	0.0871
>4 h	0.627 (0.385-1.019)	0.0597	0.770 (0.588-1.007)	0.0559
Adverse food reactions	2.017 (1.497-2.718)	<0.0001	1.699 (1.343-2.151)	<0.0001
Adverse drug reactions	1.525 (1.085-2.143)	0.0150	1.536 (1.256-1.879)	<0.0001
Education				
Elementary school or below	-	-	1.0	
Middle school	-	-	2.115 (1.563-2.861)	<0.0001
College or above	-	-	3.026 (2.176-4.209)	<0.0001
Family income (10 000 RMB)				

(Continues)

TABLE 1 (Continued)

Characters	Physician-diagnosed AR in children		Physician-diagnosed AR in adults	
	OR (95% CI) _{adj} ^a	P value	OR (95% CI) _{adj} ^a	P value
≤3	1.0		1.0	
≤6	0.994 (0.712-1.389)	0.9742	1.254 (1.005-1.565)	0.0450
>6	1.415 (1.033-1.939)	0.0306	1.579 (1.285-1.942)	<0.0001

^aMultiple logistic regression model was conducted and adjusted for region, age, race, urban, and rural group.

personal history of allergy were more likely to have AR, as in adults and children with adverse food reactions ($P < 0.0001$) and adverse drug reactions ($P < 0.0001$ and $P = 0.015$, respectively). A higher family income was also associated with a higher risk of AR; adults with an annual family income above sixty thousand RMB were more likely to have AR (OR = 1.579, 95% CI: 1.285-1.942, $P < 0.0001$) compared to adults with an income less than sixty thousand RMB (OR = 1.254, CI: 1.005-1.565, $P = 0.045$). The level of education was proportionally associated with the risk of AR. Coal- and wood-fired heating, which were common in rural areas and in families with low parental education and large number of siblings, significantly decreased the risk of AR in both children and adults, whereas other forms of heating, including central heating, did not alter the risk of AR (Table 1). It is possible that the basic living conditions and a lower level of hygiene in this area lead to a diminished allergic response to pollen. Thus, further studies on factors related to the traditional rural environment such as exposure to microbes and their products, for example, bacterial endotoxins and environmental mycobacteria⁷ that may have the potential to protect against atopic diseases, would provide important information in this regard for such remote areas.

In summary, the present study is the first multicenter epidemiological study to compare AR in children and adults in the northern grassland region of China. The results of our study indicate a high prevalence of seasonal AR in both adults and children in this region, with significant differences in the numbers of subjects with physician-diagnosed AR between the six areas. Our study further suggests that adults and children differ slightly in terms of clinical manifestations, risk factors, and pattern of allergenic sensitization. Our finding for differences in SPT sensitization patterns in children and adults is in accordance with the findings of Larenas-Linnemann et al⁸ who have demonstrated SPT sensitization to vary according to age and climatic zones in Mexico, a country with subtropical and tropical regions.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Title: Prevalence and risk factors for allergic rhinitis in adults and children living in different grassland regions of Inner Mongolia

Methods

Study region and population

We surveyed the populations in the Xilingol and Horqin Grasslands in Inner Mongolia, a northern province of China. The six areas surveyed were Tongliao, Jarud Banner, Kailu County, Xilinhot, Erenhot, and Duolun.

The target population was residents, including children and adults, who had been living permanently in Inner Mongolia for over 1 year. The population was equally distributed (1:1) by ethnic groups of Han and Mongolian, as well as residents from urban and rural areas.

Since this was a multistage, clustered, stratified random sampling study, all the subjects were selected randomly without selection bias and further stratified according to equal proportions of gender and age. Based on data obtained from the 2010 Chinese nationwide population census, the total population in the study region including the six municipalities was 1.74 million (urban: 730,928; rural: 1,011,696). The sample size of 5,000 subjects (rounded from 4,354) with equal distribution in urban and rural areas was calculated was based on an estimated prevalence of allergic rhinitis (AR) of 15%, to attain a significant level (alpha) of 0.05 and error tolerance 0.10 p (or 10%). We further estimated 20% additional subjects to account for possible noncompliance rate and thus targeted 6,000 subjects; i.e.1,000 subjects per survey area (municipality), with the same gender and age stratification. Before starting the field work, the principal investigator and key research team members met and discussed the study with the local government officials and healthcare officers in all six survey areas

(municipalities). Potential study subjects who met the criteria of residing in the survey area for more than 1 year were randomly selected. SAS software was used for all random sampling procedures and data analyses. An introduction letter was sent to each subject, followed-up by telephone call or verbal reminder from the study coordinator or local healthcare officers. In the selected clusters, when a household was contacted all the family members were invited to join the study. On the study day, the subjects reported to the survey manager with their national registration identity card (NRIC) and signed an informed consent form before participating in the study. For children or teenagers aged less than 18 years, the informed consent was signed by their parents or guardians who accompanied them to the survey site.

This study protocol was approved by the ethics committees of hospitals in Inner Mongolia and Beijing Shijitan Hospital [Ethic committee vote number (2015) Ethics Quick Trial No. 3].

Questionnaire and field interview

Demographic data were collected from children and adults; with primary information including gender, ethnic group, age, place of residence, and family income. Other information captured during the interview included the following: nasal symptoms on a month-to-month basis in the past 12 months; associated eye symptoms; other accompanied symptoms; comorbidities and complications; medical history of allergy; and other factors, including family history of AR, smoking, time of outdoor activities, mode of heating, history of pet raising, educational background, mode and duration of breastfeeding, mode of delivery, and full-term pregnancy or not (for children only) [Figure S1].

Definitions of the diagnosis

AR was diagnosed based on the criteria documented in the Allergic Rhinitis and its Impact on Asthma (ARIA) 2008 guidelines (E1). The survey subjects were asked the following question (in the questionnaire): Have you had any of the following symptoms in the past 12 months after exposure to pollens, house dust mites, or other allergens? (i) Itchy nose; (ii) Sneezing; (iii) Nasal discharge; (iv) Nasal congestion. If the answer was yes and the respondent had two or more of these symptoms, he or she was diagnosed with Self-reported AR. Furthermore, a diagnosis of Physician-diagnosed AR [Physician-AR = Self-AR & Skin prick test (SPT) (+)] was made when positive SPTs were identified to at least one of the local allergens in subjects with Self-reported AR.

Conjunctivitis was diagnosed based on the following question: Have you had any of the following eye symptoms in the past 12 months? (i) Itchy; (ii) Red; (iii) Watery. The respondent was diagnosed with conjunctivitis if he or she had any of the above symptoms (E2,-E3).

Asthma was diagnosed based on two questions. Question (1): Did you once have physician diagnosed asthma? If the answer was yes, then the respondent needed to answer Question (2): Have you had any of the following symptoms in the past 12 months? (i) Wheezing; (ii) Cough; (iii) Dyspnea; (iv) Chest tightness; (v) Shortness of breath; (vi) Arousal from sleep due to suffocation at night. Shortness of breath and arousal from sleep due to suffocation at night were additionally employed to confirm a diagnosis of asthma because these symptoms are commonly reported by asthmatic patients in the region and were likely to provide useful information, particularly as this was the first epidemiologic study to investigate the prevalence of allergic disease in this region. If the respondent answered yes to the first question and had at least one

of the six symptoms, he or she was diagnosed with asthma (E4,-E5).

Skin prick tests

SPTs were performed using standard allergen extracts and SPTs kit (Beijing Macro-Union Pharmaceutical Limited Corporation, batch number: License code: S20130002). SPTs were performed for ten commonly inhaled allergens in the northern grasslands (nine pollens and one dust mite), which were selected on the basis of information of daily local airborne pollen counts collected for up to two years prior to this study. These aeroallergens included *Dermatophagoides pteronyssinus* (DP); **Weeds:** *Artemisia* (Ar), *Humulus scandens* (Hs), *Chenopodium* (Ch); **Grass:** *Zea mays* (Ze); **Trees:** *Populus* (Po), *Salix* (Sa), *Ulmus pumila* (UI), *Juniperus chinensis* var. *chinensis* (Ju), and *Betula* (Be).

A positive reaction was defined when the diameter for the wheal resulting from allergen was ≥ 3 mm after correcting for wheal size of the negative control, and graded as follows: Class 1: diameter of wheal 3-5 mm; Class 2: diameter of wheal 5-10 mm; Class 3: diameter of wheal 1-2 cm; Class 4: diameter of wheal ≥ 2 cm or with pseudopodia.

Prior to receiving the SPTs, the subjects discontinued all first- and second-generation antihistamines for more than 3 days, some long-effect antihistamines for at least 7 days, and oral steroids for at least 4 weeks.

Results

Baseline data

A total of 6,200 inhabitants (age 0-79 years) were recruited; of whom 6,043 (response rate, 97.5%) completed the questionnaire and SPTs. We surveyed six regions in Inner

Mongolia. The number of respondents surveyed in each of the six areas was 1,008 in Erenhot, 842 in Xilingol, 1,028 in Duolun, 1,022 in Kailu, 1,000 in Tongliao, and 1,143 in Jarud Banner ([Table S1](#)).

Prevalence of AR

The prevalence of Self-reported AR and Physician-diagnosed AR was 32.4% (1,958/6,043) and 18.8% (1,134/6,043), respectively. The prevalence of AR was found to be higher in urban areas than in rural areas ($P<0.0001$), but was not significantly higher in Han people than in Mongolian people. The prevalence of Physician-diagnosed AR between the six areas was significantly different ($P<0.0001$). In addition, the prevalence of Physician-diagnosed AR in males (19.9%) was significantly higher than females (17.7%) ($P=0.0305$) ([Table S1](#)).

The prevalence of Physician-diagnosed AR increased till the peak age interval of AR onset was 18-39 years and then decreased until reaching the lowest in those aged above 60 years ([Figure S2](#)).

Results of SPTs

A total of 6,043 subjects completed SPTs for nine pollens and one house dust mite. In patients with Physician-diagnosed AR, the positive rate of SPTs for allergens is shown in [Figure S3](#), and the patterns of allergic sensitization by SPTs in patients with AR are shown in [Figure S4](#) and [Figure S5](#). Most patients with AR were poly-sensitized to more than three pollen types (67.6%). The top SPT-positive allergens were *Artemisia* species, *Chenopodium*, and *Humulus scandens*, which are also the most common pollens in the geographic area studied ([Figure S3](#)). A significant difference in the pattern of allergen sensitization was observed between children and adults with

Physician-diagnosed AR ([Figure S4](#), [Figure S5](#)). Children more frequently showed a mono-sensitization pattern than adults ($P<0.0001$), while adults more frequently showed a poly-sensitization pattern ($P<0.0001$) ([Figure S4](#)).

Clinical and associated symptoms and peak presence of AR symptoms

Among subjects with Physician-diagnosed AR, the nasal symptoms (ranked by decreasing order of frequency) included: sneezing, itchy nose, nasal discharge, nasal congestion, postnasal drip, and hyposmia. The frequency of other symptoms is shown in [Table S3](#).

Among symptoms associated with AR, adults had more conspicuous fatigue and somnolence than children ($P<0.0001$), whereas children were more likely to have abdominal pain than adults ($P<0.005$) ([Table S3](#)).

For both adults and children, there were two peak onset periods of Physician-diagnosed AR during the year. The first peak occurred in April, and the second peak occurred in July and August ([Figure 2, A](#)). The peaks were slightly different in the six regions ([Figure 2, B-G](#)).

Comorbidities

Children with AR were more likely to also have asthma compared with adults (19.7% vs. 13.5%). Adults with Physician-diagnosed AR were more likely to have conjunctivitis than children ($P=0.0029$). In adults with Physician-diagnosed AR, 16.6% ($n=130$) had hypertension, 13.2% ($n=103$) had heart disease, and 3.8% ($n=30$) had diabetes ([Table S4](#)).

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Legends of Figures

Fig S1 Epidemiological questionnaire.

Fig S2 The prevalence of Physician-diagnosed AR by age groups in 2015.

Fig S3 Allergic sensitizations to pollen based on positive SPTs in adults and children with Physician-diagnosed AR.

Ar, *Artemisia species*; Be, *Betula*; Ch, *Chenopodium*; DP, *Dermatophagoides*

pteronysinus; Hu, *Humulus scandens*; Ju, *Juniperus chinensis var. chinensis*; Po,

Populus; Sa, *Salix*; Ul, *Ulmus pumila*; Ze, *Zea mays*.

FigS4 Pattern of allergic sensitization to pollen based on positive SPTs in adults and children with Physician-diagnosed AR sensitized to at least one tested allergen (* $P<0.0001$). Monosensitized = sensitization to one allergen; Oligosensitized = sensitization to two pollens; Polysensitized = sensitization to three or more pollens.

Fig S5 The pattern of allergic sensitizations to tree, grass and weed allergens based on positive SPTs in adults and children with Physician-diagnosed AR (* $P<0.0001$, # $P<0.05$).

Table S1. The prevalence of Physician-diagnosed AR by sociodemographic characteristics among adults and children.

Variable	Children, N=2443			Adults, N=3600		
	Total	Physician-diagnosed AR		Total	Physician-diagnosed AR	
		AR, n (%)	P value*		AR, n (%)	P value*
Prevalence	2443	351 (14.4)		3600	783 (21.8)	
Gender			0.0231			0.1192
Male	1255	200 (15.9)		1645	377 (22.9)	
Female	1188	151 (12.7)		1955	406 (20.8)	
Races/ethnics			0.2432			0.0435
Han	1192	172 (14.4)		2096	426 (20.3)	
Mongolian	1123	167 (14.9)		1363	326 (23.9)	
Other	128	12 (9.4)		141	31 (22.0)	
Residence			<0.0001			<0.0001
Urban	1206	254 (21.1)		1755	437 (24.9)	
Rural	1237	97 (7.8)		1842	346 (18.8)	

*Chi-square test.

Table S2. Prevalence of Physician-diagnosed AR by sociodemographic characteristics in the northern grasslands of China.

Variable	Physician-diagnosed AR, n (%)		<i>P</i> value (AR vs no AR)
	No	Yes	
Prevalence	4909 (81.2)	1134 (18.8)	
Age (y), mean $\pm$ SD	29.4 (21.7)	29.9 (16.6)	0.4576
Age group (y)			
0-6y	956 (93)	72 (7.0)	<0.0001
7-12y	793 (83.9)	152 (16.1)	
13-17y	323 (72.1)	125 (27.9)	
18-39y	1051 (69.5)	461 (30.5)	
40-59y	1279 (82.4)	274 (17.6)	
≥ 60 y	487 (91.0)	48 (9.0)	
Gender			
Male	2323 (80.1)	577 (19.9)	0.0305
Female	2586 (82.3)	557 (17.7)	
Races/ethnics			

Han	2690 (81.8)	598 (18.2)	0.1397
Mongolian	1993 (80.2)	493 (19.8)	
Other	226 (84.0)	43 (16.0)	
Residence			
urban	2270 (76.7)	691 (23.3)	<0.0001
rural	2636 (85.6)	443 (14.4)	
Region			
Xilinhot	574 (68.2)	268 (31.8)	<0.0001
Duolun	887 (86.3)	141 (13.7)	
Erenhot	763 (75.7)	245 (24.3)	
Tongliao	911 (89.1)	111 (10.9)	
Jurad	900 (78.7)	243 (21.3)	
Kailu	874 (87.4)	126 (12.6)	

*Chi-square test and t test were performed.

Table S3. Symptoms associated with Physician-diagnosed AR in children and adults.

Symptoms	Physician-diagnosed AR, N=1134				
	Total	Adults	Children	<i>P</i> value*	
	n=1958	n=1308	n=650		
Rhinitis associated symptoms					
Itchy Nose	1023 (90.2)	725 (92.6)	298 (84.9)	<0.0001	
Sneeze	1084 (95.6)	754 (96.3)	330 (94.0)	0.0839	
Nasal discharge	945 (83.3)	675 (86.2)	270 (76.9)	0.0001	
Nasal congestion	891 (78.6)	603 (77.0)	288 (82.1)	0.0559	
Postnasal drip	309 (27.3)	234 (29.9)	75 (21.4)	0.0029	
Hyposmia	389 (34.3)	314 (40.1)	75 (21.4)	<0.0001	
Eye symptoms					
Itchy	732 (64.6)	530 (67.7)	202 (57.6)	0.0010	
Red	577 (50.9)	420 (53.6)	157 (44.7)	0.0055	
Tearing	548 (48.3)	419 (53.5)	129 (36.8)	<0.0001	
Non-Rhinitis associated symptoms					

Fatigue	356 (31.4)	299 (38.2)	57 (16.2)	<0.0001
Somnolence	360 (31.8)	303 (38.7)	57 (16.2)	<0.0001
Mouth ulcer	237 (21.0)	170 (21.8)	67 (19.1)	0.3008
Diarrhea	149 (13.2)	113 (14.5)	36 (10.3)	0.0534
Constipation	202 (17.8)	128 (16.4)	74 (21.1)	0.0552
Abdominal pain	134 (11.8)	86 (11.0)	48 (13.7)	0.1942

* Chi-square test was performed to compare adults and children.

Table S4. Other diseases associated with Physician-diagnosed AR in adults and children

Disease	Physician-diagnosed AR, N=1134			<i>P</i> value*
	Total n=1134	Adult n=783	Children n=351	
Asthma	175 (15.4)	106 (13.5)	69 (19.7)	0.0084
Conjunctivitis	768 (67.7)	552 (70.5)	216 (61.5)	0.0029
Hypertension	130 (11.5)	130 (16.6)	-	
Heart disease	103 (9.1)	103 (13.2)	-	
Diabetes	30 (2.7)	30 (3.8)	-	

* Chi-square test was performed to compare adults and children.

Table S5.The differential risk for Physician-diagnosed AR in relation to the type of obesity in adults.

Characteristic	Adult, n=3600		
	Non- AR	AR	P value
Body mass index, kg/m ²			
<18.5	105 (73.43)	38 (26.57)	0.4725
18.5-24	1144 (79.01)	304 (20.99)	
24-28	1028 (77.94)	291 (22.06)	
>=28	539 (78.23)	150 (21.77)	

Questionnaire
Demographic information

Study ID: _____

Name: _____ Sex: 1 Male ☐ 2 Female ☐

ID card number: _____ Telephone number: _____

Actual date of birth: _____ Year _____ Month _____ Day _____

Nation: 1 Han ☐ 2 Mongolian ☐ 3 Other ☐

Level of education: 1 Elementary school or below ☐ 2 Middle School ☐ 3 University or above ☐

Height: _____ cm Weight: _____ kg Waist circumference: _____ cm

What is the total income last year in your household? (10,000 RMB)
I ≤3 _____ II ≤6 _____ III >6 _____

Current residence: 1 Urban areas ☐ 2 Rural areas ☐

Rhinitis

1 Do you have the following symptoms repeatedly in the past 12 months? 1 Yes ☐ 2 No ☐
(If no, go to next section)

	1 Yes	2 No
Itchy nose	☐	☐
Sneeze	☐	☐
Nasal discharge	☐	☐
Nasal congestion	☐	☐
Nasal mucus reflux (flow to throat)	☐	☐
Hyposmia	☐	☐

2 In what occasion did the symptoms occur?
I Perennial without seasonal change ☐ (If so, go to next section) II Perennial with seasonal exacerbation ☐
III Seasonal ☐ IV Occasional ☐

3 If the symptoms were seasonal or perennial with seasonal exacerbation, in which months did they occur in the past 12 months? (Multiple choices)

January	February	March	April	May	June	July	August	September	October	November	December
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Conjunctivitis

1 Do you have the following symptoms repeatedly in the past 12 months? 1 Yes ☐ 2 No ☐
(If no, go to next section)

	1 Yes	2 No
Eyes itch	☐	☐
Eyes red	☐	☐
Tearing	☐	☐

2 In what occasion did the symptoms occur?
I Perennial without seasonal change ☐ (If so, go to next section) II Perennial with seasonal exacerbation ☐
III Seasonal ☐ IV Occasional ☐

Asthma

1 Did you once have physician diagnosed asthma in the past 12 months?
If the answer was yes, then the respondent needed to answer Question 2:

2 Have you had any of the following symptoms in the past 12 months?
1 Wheezing II Cough III Dyspnea IV Chest tightness V Shortness of breath VI Arousal from sleep due to suffocation at night.

Urticaria

1 Have you ever had the symptoms of erythema, wheal in the past 12 months?
1 Yes ☐ 2 No ☐ (If no, go to next section)

2 Did the urticaria regress spontaneous within 24 hours? 1 Yes ☐ 2 No ☐

3 Did the urticaria regress without traces? 1 Yes ☐ 2 No ☐

Related symptoms

Do you have the following symptoms in the past 12 months?
1 Fatigue 2 Somnolence 3 Mouth ulcer 4 Diarrhea 5 Constipation 6 Abdominal pain

Medical history

1 Have you ever had the following diseases?

Diagnosed disease	1 Yes	2 No
Hypertension	☐	☐
Heart disease	☐	☐
Diabetes	☐	☐

2 Have you ever had the history of food allergy? (If yes, please indicate.) 1 Yes ☐ 2 No ☐

3 Have you ever had the history of drug allergy? (If yes, please indicate.) 1 Yes ☐ 2 No ☐

4 Do you use antibiotics frequently? (>3 times per year.) 1 Yes ☐ 2 No ☐

Risk factors

1 Do your family members who are related to you in blood had the nasal symptoms (nose itch, runny nose, sneeze, nasal obstruction) repeatedly?

	1 Yes	2 No
Grandfather	☐	☐
Grandmother	☐	☐
Maternal grandfather	☐	☐
Maternal grandmother	☐	☐
Father	☐	☐
Mother	☐	☐
Brother	☐	☐
Sister	☐	☐

2 Do you have a pet dog or cat in your house? 1 Yes ☐ 2 No ☐

3 What was the main cooking fuel/heating fuel used in your house?
1 Central heating ☐ 2 Coal heating ☐ 3 Wood heating ☐ 4 Others ☐

4 What is the usual duration of your outdoor activities per day?
1 <1 Hours ☐ 2 1-2 Hours ☐ 3 2-3 Hours ☐ 4 3-4 Hours ☐ 5 >4 Hours ☐

5 Have you ever smoked any tobacco?
1 Never smoking ☐ 2 Now smoking ☐ 3 Ever smoking ☐

The following questions are for children only

6 Were you born at full term? 1 Yes ☐ 2 No ☐

7 Which birth mode were you? 1 Natural labour ☐ 2 Cesarean delivery ☐

8 Which feeding mode were you? 1 Breast feeding only ☐ 2 Mixed feeding ☐

9 Were you breastfed for more than 6 months in infancy? 1 Yes ☐ 2 No ☐

Signature of interviewer _____
Date: _____

Fig. S1 Epidemiological questionnaire

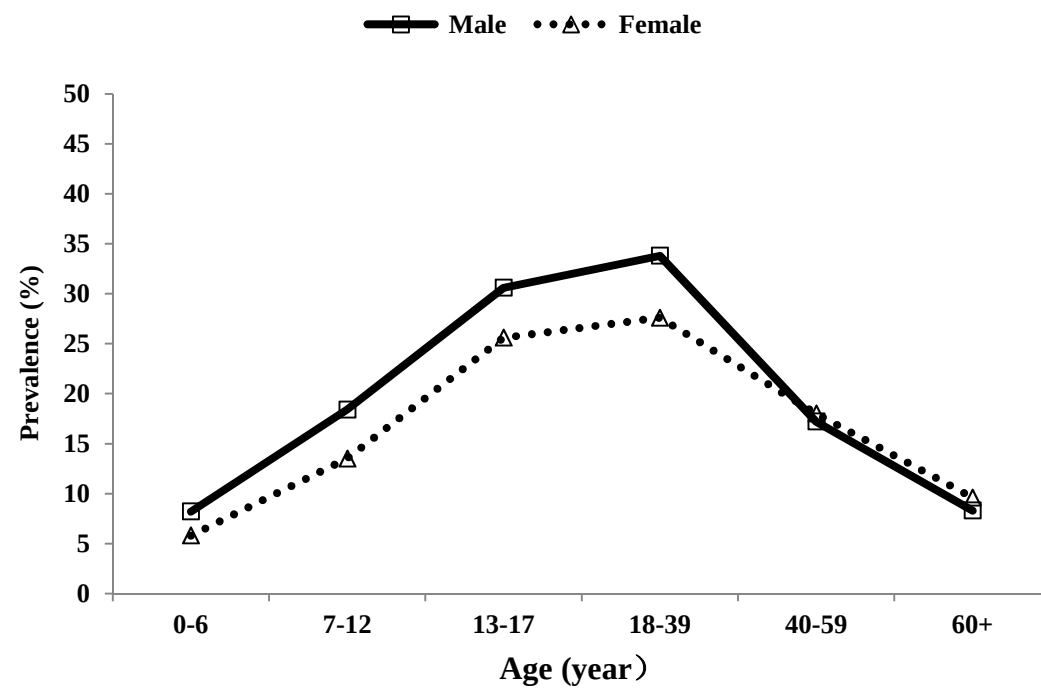


Fig. S2 The prevalence of Physician-diagnosed AR by age group in 2015.

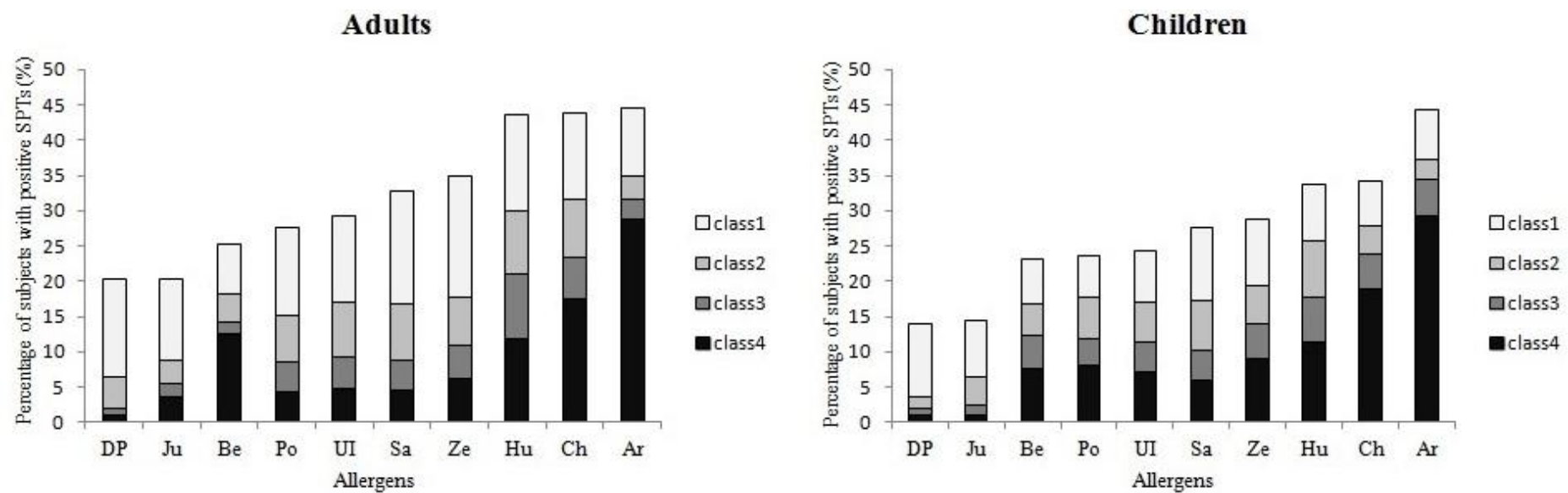


Fig. S3 Allergic sensitization to different allergens based on positive SPTs in adults and children with Physician-diagnosed AR.

Ar, *Artemisia species*; Be, *Betula*; Ch, *Chenopodium*; DP, *Dermatophagoides pteronyssinus*; Hu, *Humulus scandens*; Ju, *Jchinensuniperus is var. chinensis*; Po, *Populus*; Sa, *Salix*; UI, *Ulmus pumila*; Ze, *Zea mays*.

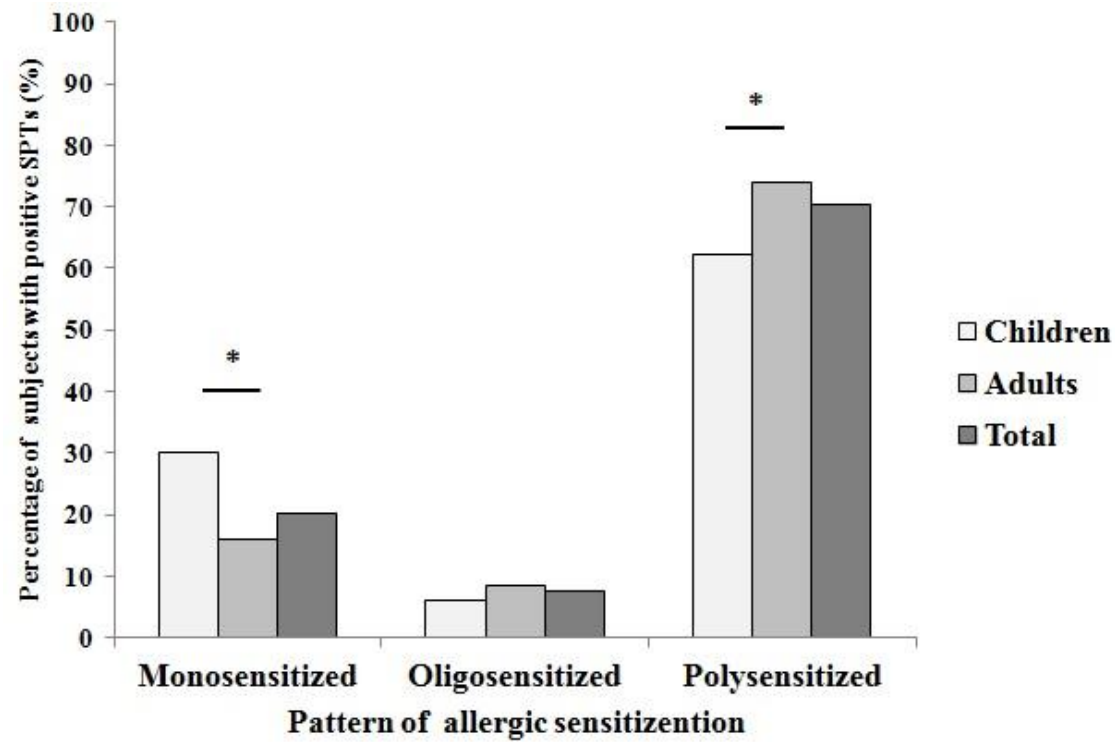


Fig. S4 Pattern of allergic sensitization based on positive SPTs to more than one allergen in adults and children with Physician-diagnosed AR. (* $P < 0.0001$).

Monosensitized = sensitization to one allergen; Oligosensitized = sensitization to two pollens; Polysensitized = sensitization to three or more pollens.

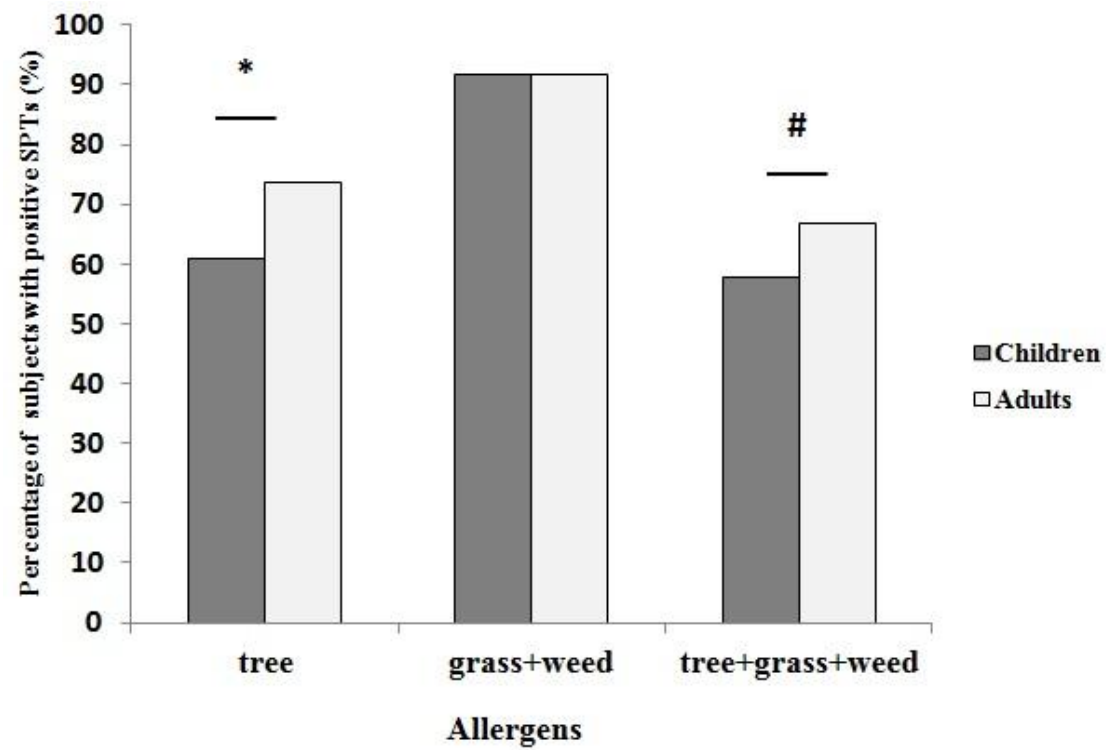


Fig. S5 The pattern of allergic sensitizations to tree and grass allergens based on positive SPTs in adults and children with Physician-diagnosed AR (* $P < 0.0001$, # $P < 0.05$).