Prevalence of allergen sensitization among children with allergic rhinitis in Changzhou, China: a retrospective observational study

Zhibang Hu[1], Jianrong Xue[1], Min Pan[2], Yongzheng Bao[1], Wenlan Zou[1], Chunhui Wang[1] and Jing Ma[1*]

Abstract

Objective To determine the prevalence of sensitivity to common inhaled and food allergens among children with allergic rhinitis (AR) in Changzhou in eastern China and provide a basis for epidemiological research of pediatric allergic rhinitis and allergen avoidance in this region.

Methods This was a retrospective observational study, a total of 1248 children with AR were enrolled at the Third People's Hospital of Changzhou between January 2018 and December 2019. The serum-specific immunoglobulin E (sIgE) to 19 kinds of inhaled and food allergens and serum total IgE were detected with the AllergyScreen test (Mediwiss Analytic GmbH, Moers, Germany). All participants had a positive reaction to at least one allergen in the test (the sIgE concentration ≥ 0.35 IU/ml).

Results Among the patients, 818 (65.54%) were male and 430 (34.46%) were female, with 81 (6.50%) aged 1–3 year, 501 (40.14%) aged 4–7 year, and 666 (53.36%) aged 8–14 year. The positivity rate of inhaled allergens was 80.05% ($n = 999$), while the positivity rate of food allergens was 66.19% ($n = 826$). 828 patients (66.35%) were sensitized to multiple allergens. The most common inhaled allergens were *Dermatophagoides pteronyssinus* (65.38%), mold mix (25.56%), house dust (20.67%), and dog hair dander (13.94%), and the most common food allergens were cow's milk (30.31%), cashew nut (27.9%), egg (22.68%), and beef (12.98%). With an increase in age, the inhaled allergen positivity rate showed a significant increase ($P < 0.01$), while the food allergen positivity rate decreased significantly ($P < 0.01$). There were significant age differences in total IgE levels ($P < 0.01$) and the total IgE level was highest in the group aged 8–14 year.

Conclusions *Dermatophagoides pteronyssinus* was the most common sensitizing allergen in pediatric patients with AR in Changzhou. Several other inhaled and food allergens were also common. We observed that multiple allergenic factors play an important role in the occurrence and development of AR.

Keywords Allergen, Children, Prevalence, Specific IgE, Changzhou, China

*Correspondence:
Jing Ma
majing6410@aliyun.com
[1]Department of Otorhinolaryngology, the Third People's Hospital of Changzhou, Changzhou 213001, China
[2]Department of Pharmacy, the Third People's Hospital of Changzhou, Changzhou 213001, China

Allergic rhinitis (AR) is a non-infectious, chronic inflammatory disease of the nose mediated by IgE after exposure to allergens in atopic individuals of all ages, especially children and adolescents [1, 2]. The worldwide prevalence rate of AR is 10–40% and it affects more than 20% of the Chinese population, a trend that is increasing yearly [3–5]. Because it influences the occurrence, development, and treatment outcomes of lower respiratory tract inflammatory diseases, especially bronchial asthma, AR seriously reduces quality of life in children, increases the family medical expenditure, and directly or indirectly causes serious medical consequences and social burden [3]. Pediatric AR treatment mainly includes environmental control, medications, and immunotherapy [6]. The primary goal of AR treatment in children is to improve their living environment by reducing allergen exposure, especially as an early intervention for infants [7]. These reduction measures can help to reduce the production of specific IgE and may even eradicate the allergen sensitization state. Clinically, children with AR present with multiple sensitization factors [8]. Analysis of the distribution characteristics of allergens, especially those that are specific to AR, can provide an important reference for the diagnosis and treatment of this disease [9]. In this study, we analyzed the allergen sensitivity status in children with AR in Changzhou, eastern China, to facilitate the prevention, diagnosis, and management of AR in this region.

Methods

Study design

In this retrospective study, a total of 1248 consecutive pediatric patients diagnosed with AR by in vitro assay of specific IgE (sIgE) to common allergens were enrolled from January 2018 to December 2019 in the Third People's Hospital of Changzhou, Jiangsu Province, China. All children with AR were in compliance with the Chinese guidelines for the diagnosis and treatment of AR in children [4, 10]. All participating children had tested positive for sIgE to at least one of the 19 allergens (the sIgE concentration≥0.35 IU/ml).

AllergyScreen test

A total of 19 inhaled and food allergen-specific lgE (sIgE) and total serum IgE levels were measured in serum using the AllergyScreen test (Mediwiss Analytic GmbH, Moers, Germany) and its specialized in vitro allergen diagnostic reagents according to the manufacturer's protocol. Inhaled allergens included *Dermatophagoides pteronyssinus*, house dust, mulberry, cat dander, dog hair, cockroach, amaranth, mold mix, grass mix, and tree pollen mix. The food allergens included egg, cow's milk, shrimp, beef, shellfish, crab, mango, cashew nut, and pineapple. The results were semi-quantified and classified with the following grading criteria: grade 0 (<0.35 IU/ml); grade

I (0.35–0.70 IU/ml); grade II (0.71–3.5 IU/ml); grade III (3.6–17.5 IU/ml); grade IV (17.6–50 IU/ml); grade V (51–100 IU/ml); and grade VI (>100 IU/ml). A sIgE concentration≥0.35 IU/ml was considered positive. The total serum IgE level was divided into three groups: the low-concentration group (<100 IU/ml); the medium-concentration group (100–200 IU/ml); and the high-concentration group (>200 IU/ml).

Sample size

Our center was the largest diagnosis and treatment center for allergic rhinitis in Changzhou, and the number of patients in our center during the study period determined the sample size.

Statistical analysis

All data were analyzed using the IBM SPSS Statistics version 21. The sIgE positivity rates were compared with the chi-squared test or Fisher's exact probability method and total IgE levels were compared with the Kruskal-Wallis test and the Mann-Whitney U test. $P<0.05$ was considered statistically significant.

Results

Overall positivity rate of sIgE with inhaled and food allergens

420 patients (33.65%) were sensitized to only one allergen, and 828 patients (66.35%) were sensitized to multiple allergens. The positivity rate of serum inhaled allergens in children with AR was 999(80.05%), significantly higher than the food allergen positivity rate of 826(66.19%) ($P<0.01$). The most common inhaled allergens were *D. pteronyssinus* 816 (65.38%), mold mix 319 (25.56%), house dust 258 (20.67%), and dog hair 174 (13.94%). Similarly, among the food allergens, positivity rates of sIgE to cow's milk 377 (30.21%), cashew nut 349 (27.9%), egg 283 (22.68%), and beef 162 (12.98%) were more frequent (Table 1).

Allergen sensitization in different sex and age groups

The positivity rates of overall inhaled allergens in both boys (81.05%, 663/818) and girls (78.14%, 336/430) were significantly higher than the positivity rates of food allergens in boys (65.77%, 538/818) and girls (66.98%, 288/430) ($P<0.01$) (Table 2). There were no sex differences in the overall positive rates of inhaled (81.05% vs. 78.14%) and food allergens (65.77% vs. 66.98%) ($P>0.05$) (Table 2). However, the sIgE positive rates of mulberry, cat dander, dog hair, amaranth, beef, and crab were higher among males than females ($P<0.05$) (Table 3).

All children were divided into three groups based on age (1–3, 4–7, and 8–14 year). The sensitization to total inhaled and food allergens was significantly different among age groups ($P<0.01$) (Table 4). The positivity rate

Hu *et al. BMC Pediatrics*   (2023) 23:466

Page 3 of 6

Table 1 The positivity rate of sIgE with inhaled and food allergens

Allergens		Negative (Grade 0)	Positive						Total	Ranking
			Grade I	Grade II	Grade III	Grade IV	Grade V	Grade VI		
Inhaled	D. pteronyssinus	432 (34.62%)	33	95	234	225	105	124	816 (65.38%)	1
	House dust	990 (79.33%)	105	141	9	2	0	1	258 (20.67%)	6
	Mulberry	1215 (97.36%)	12	18	2	1	0	0	33 (2.64%)	17
	Cat dander	1107 (88.70%)	20	65	46	7	0	3	141 (11.30%)	10
	Dog hair	1074 (86.06%)	82	86	4	2	0	0	174 (13.94%)	7
	Cockroach	1201 (96.23%)	27	17	2	0	1	0	47 (3.77%)	15
	Amaranth	1168 (93.59%)	29	26	20	5	0	0	80 (6.41%)	13
	Mold mix	929 (74.44%)	46	95	134	36	7	1	319 (25.56%)	4
	Grass mix	1217 (97.52%)	13	11	6	1	0	0	31 (2.48%)	18
	Tree pollen mix	1175 (94.15%)	34	32	5	1	1	0	73 (5.85%)	14
Food	Egg	965 (77.32%)	148	115	15	1	4	0	283 (22.68%)	5
	Cow's milk	871 (69.79%)	152	210	13	1	0	1	377 (30.21%)	2
	Shrimp	1136 (91.03%)	56	29	20	3	0	4	112 (8.97%)	11
	Beef	1086 (87.02%)	120	42	0	0	0	0	162 (12.98%)	8
	Shellfish	1203 (96.39%)	41	3	1	0	0	0	45 (3.61%)	16
	Crab	1092 (87.50%)	70	46	26	8	1	5	156 (12.50%)	9
	Mango	1161 (93.03%)	68	16	3	0	0	0	87 (6.97%)	12
	Cashew nut	899 (72.04%)	163	132	41	13	0	0	349 (27.96%)	3
	Pineapple	1224 (98.08%)	16	8	0	0	0	0	24 (1.92%)	19

Table 2 The positivity rates of overall inhaled and food allergens compared by sex

Allergens	Inhaled	Food	P value
Male	663 (81.05%)	538 (65.77%)	<0.001
Female	336 (78.14%)	288 (66.98%)	<0.001
P value	0.22	0.67	

Table 3 Allergen sensitization compared by sex

Allergens	Number of sIgE-positive patients (%)		P value
	Male	Female	
D. pteronyssinus	542(66.26%)	274(63.72%)	0.37
House dust	169(20.66%)	89(20.70%)	0.99
Mulberry	29(3.55%)	4(0.93%)	0.01
Cat dander	105(12.84%)	36(8.37%)	0.02
Dog hair	130(15.89%)	44(10.23%)	0.01
Cockroach	33(4.03%)	14(3.26%)	0.49
Amaranth	64(7.82%)	16(3.72%)	0.01
Mold mix	208(25.43%)	111(25.81%)	0.88
Grass mix	22(2.69%)	9(2.09%)	0.52
Tree pollen mix	50(6.11%)	23(5.34%)	0.59
Egg	173(21.15%)	110(25.58%)	0.08
Cow's milk	258(31.54%)	119(27.67%)	0.16
Shrimp	82(10.02%)	30(6.98%)	0.07
Beef	118(14.43%)	44(10.23%)	0.04
Shellfish	25(3.06%)	20(4.65%)	0.15
Crab	117(14.30%)	39(9.07%)	0.01
Mango	54(6.60%)	33 (7.67%)	0.48
Cashew nut	242(29.58%)	107(24.88%)	0.08
Pineapple	18(2.20%)	6 (1.39%)	0.33

Table 4 Allergen sensitization in different age groups

Allergens	Number of sIgE-positive patients (%)			P value
	1–3 yr	4–7 yr	8–14 yr	
Number of patients	81	501	666	
Inhaled	49 (60.49%)	357 (71.26%)	593 (89.04%)	<0.001
Food	68 (83.95%)	366 (73.05%)	392 (58.86%)	<0.001

of inhaled allergens increased with age, while conversely, the positivity rate of food allergens decreased with age. The positivity rate of inhaled allergens in children aged 1–3 year was lower than that of food allergens (*P*<0.01). The opposite trend was observed in children aged 8–14 year (*P*<0.01). The inhaled allergen sIgE positivity rates of *D. pteronyssinus*, house dust, cat dander, amaranth, and mixed mold were low in the 1–3 year group and increased with age, while the positivity rates of egg, cow's milk, crab, and cashew showed the opposite trend (Table 5).

Characteristics of the total serum IgE level distribution

As shown in Table 6, there were 164 children with total IgE<100 IU/ml, including 96 boys and 68 girls, with the following age distribution: 1–3 year (*n*=16); 4–7 year (*n*=92); and 8–14 year (*n*=56). Total IgE ranged from 100 to 200 IU/ml in 79 patients, including 49 boys and 30 girls, as follows: 1–3 year (*n*=8); 4–7 year (*n*=30); and 8–14 year (*n*=41). A total of 1005 patients were classified in the high-concentration group, including 673 boys and 332 girls: 1–3 year (*n*=57); 4–7 year (*n*=379); and 8–14 year (*n*=569). There was no significant sex difference in total IgE level (*P*>0.05), but there was a

Hu *et al. BMC Pediatrics*   (2023) 23:466

Page 4 of 6

Table 5 The positivity rate of sIgE in different age groups

Allergens	Number of sIgE-positive patients (%)			P value
	1–3 yr	4–7 yr	8–14 yr	
	n = 81	n = 501	n = 666	
D. pteronyssinus	23 (28.40%)	284 (56.69%)	509 (76.43%)	< 0.001
House dust	10 (12.35%)	79 (15.77%)	169 (25.38%)	< 0.001
Mulberry	0 (0%)	16 (3.19%)	17 (2.55%)	0.25
Cat dander	24 (29.63%)	61 (12.18%)	56 (8.41%)	< 0.001
Dog hair	17 (20.99%)	74 (14.77%)	83 (12.46%)	0.09
Cockroach	2 (2.47%)	13 (2.59%)	32 (4.80%)	0.11
Amaranth	0(0%)	24(4.79%)	56(8.41%)	0.002
Mold mix	11(13.58%)	156(31.14%)	152(22.82%)	< 0.001
Grass mix	1(1.23%)	10 (2.00%)	20 (3.00%)	0.42
Tree pollen mix	4 (4.94%)	33 (6.59%)	36 (5.41%)	0.65
Egg	34 (41.98%)	136 (27.15%)	113 (16.97%)	< 0.001
Cow's milk	42 (51.85%)	173 (34.53%)	162 (24.32%)	< 0.001
Shrimp	12 (14.81%)	43 (8.58%)	57 (8.56%)	0.16
Beef	12 (14.81%)	67 (13.37%)	83 (12.46%)	0.79
Shellfish	6 (7.41%)	20 (3.99%)	19 (2.85%)	0.10
Crab	19 (23.46%)	68 (13.57%)	69 (6.46%)	0.002
Mango	6 (7.41%)	38 (7.58%)	43 (6.46%)	0.75
Cashew nut	39 (48.15%)	168 (33.53%)	143 (21.47%)	< 0.001
Pineapple	1 (1.23%)	9 (1.80%)	14 (2.10%)	0.84

Table 6 Total serum IgE level in different age groups

Total IgE	< 100 IU/ml	100–200 IU/ml	> 200 IU/ml	
1–3 yr	16	8	57	81
4–7 yr	92	30	379	501
8–14 yr	56	41	569	666
	164	79	1005	1248

significant age difference (*P* < 0.01) and the total IgE level increased with age.

Discussion

Allergic rhinitis is one of the most common allergic diseases in children, which not only leads to a decline in quality of life but also affects school performance [2, 11]. The prevalence of AR has increased significantly worldwide, with differing regional main types of allergens and prevalence. A cross-sectional study showed an AR prevalence of 11.7–21.2% in Europe [12] and the worldwide AR prevalence is expected to increase further over the coming decades. A survey conducted in 11 major cities in China showed that the self-reported prevalence of AR was about 8.7–24.1% [13].

The etiology of AR is still unclear and its pathogenesis is likely related to the combined influences of both genetic and environmental factors [3, 14]. Allergen sensitization is one factor that plays a key role in the development of AR and has an important impact on prognosis for children with AR [15]. Allergen avoidance is the primary strategy for AR treatment [16]. Strategies for reducing the generation of allergen-related sIgE include changing

and controlling the living environment, reducing allergen contact during exposure, and avoiding allergen exposure, especially in infants. Such measures may even lead to complete remission of the allergen sensitization state. Several studies have shown that reducing allergen exposure can reduce clinical symptoms and improve quality of life in patients with perennial AR, as well as nasal and eye-related symptoms in patients with allergic nasal conjunctivitis [17, 18]. However, allergens are affected by multiple factors such as regional environment, climate, temperature, and humidity [19]. Consequently, different AR triggers are found in different geographic and situational locales. Therefore, clarifying the characteristics of allergen distribution in this region of China is important for the prevention and treatment of AR.

The results of this study showed the most common inhaled allergen in children with AR in Changzhou was *D. pteronyssinus* and the positive detection rate of inhalation allergens is significantly higher than that of food allergens, which is similar to results of several previous studies [20–22]. The second-ranked inhaled allergen was a mold mix of spot penicillin, crossstrepsporum, mycospore, and *Aspergillus fumigatus*. This finding may be related to Changzhou's location in a subtropical monsoon climate area conducive to the breeding of mites and mold, as well as the centralized treatment of local allergen-positive children. At the same time, the positive rate of dog hair and cat dander in this study was also high, likely because Changzhou is located in an economically developed area of China, with high living standards and more pet breeding.

Some studies have demonstrated that allergic diseases are more common in females than in males [23, 24], while other studies have reported higher allergen sensitization rates in men than in women [25, 26]. We found no sex differences in the positivity rates of inhaled and food allergens, which is consistent with the findings in some previous studies [27, 28]. The reason for the difference remains unclear and further studies should be conducted to explain any observed sex-related differences. The sIgE positivity rates of mulberry, cat dander, dog hair, amaranth, beef, and crab were higher among males than females. The reason for this difference may be related to different exposure opportunities to different allergens and differences in immune function between males and females. We also found that the positivity rates of overall inhaled allergens in boys and girls were significantly higher than that of food allergens, which may be related to the fact that most of the patients in our center have AR.

The characteristics of allergen sensitization in children with AR of different ages vary. Several epidemiological studies on allergic diseases showed that infants < 2 year mainly tested positive for food allergens, while

school-aged children mainly tested positive for inhalation allergens [29–31]. Consistent with this trend, the overall positivity rate of inhaled allergens in the 1–3 year group was lower than that of food allergens, while the highest percentage of children sensitized to inhaled allergens was observed in the 8–14 year group. At the same time, the inhaled allergen sIgE positive rates including *D. pteronyssinus*, house dust, cat dander, amaranth, and mixed mold were low in the 1–3 year group and increased with age, while the positivity rates of egg, cow's milk, crab, and cashew showed the opposite trend. We also found that total serum IgE levels increased with age, suggesting that the allergic status in children with AR may be progressive without the implementation of effective allergen avoidance and control.

Notably, this study had some limitations. First, children had numerous daily exposure to allergens, but only the positive rate of sIgE was analyzed in this study. Second, the present study was retrospective in nature and may have a bias associated with patient selection. Finally, the severity of AR cannot be assessed by allergen distribution. Allergens are greatly affected by geographical and environmental factors, and this study only reflected the allergen distribution of children with AR in this region. Strategies to improve the rigor of future studies include expansion of the sample size and grouping of patients by disease severity to explore whether severity correlates with the positivity rate of allergens.

Conclusion

The prevalence and distribution of allergens in pediatric patients with AR in Changzhou exhibited differences in sex and age, and *Dermatophagoides pteronyssinus* is the most common allergen in Changzhou. These findings may be helpful to provide a basis for epidemiological research in children with allergic rhinitis in this region and guide more evidence-based and individualized prevention and treatment of this disease. The findings of this study may also be applicable to patients in other regions with similar climatic conditions and lifestyles in eastern China.

Authors' contributions
Prof. Jing Ma and Dr. Jianrong Xue conceptualized and designed the study, thoroughly reviewed and revised the manuscript. Dr. Zhibang Hu and Dr. Chunhui Wang designed the data collection tables, coordinated and supervised data collection, and drafted the initial manuscript. Dr. Min Pan, Dr. Yongzheng Bao and Dr. Wenlan Zou collected data, carried out the initial analyses, and reviewed and revised the manuscript. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Declarations

Ethical approval and consent to participate
This study was approved by the Ethics committee of The Third People's Hospital of Changzhou (Ethic number:02 A-A20220017). Due to the retrospective nature of this study, Informed consent was waived by the Ethics committee of The Third People's Hospital of Changzhou. All study methods were carried out in accordance with relevant guidelines and regulations (declaration of helsinki).

Consent for publication
Not applicable.

Conflict of interest
The authors have declared they have no conflicting interests.

Competing interests
The authors declare no competing interests.

References
1. Asher MI, Montefort S, Björkstén B, Lai CKW, Strachan DP, Weiland SK, et al. Worldwide time trends in the prevalence of symptoms of asthma, allergic rhinoconjunctivitis, and eczema in childhood: ISAAC Phases one and three repeat multicountry cross-sectional surveys. Lancet. 2006. August;26368(9537):733–43.
2. Schuler Iv CF, Montejo JM. Allergic rhinitis in children and adolescents. Pediatr Clin North Am. 2019;66(5):981–93. https://doi.org/10.1016/j.pcl.2019.06.004. Epub 2019 Aug 5. PMID: 31466686.
3. Brożek JL, Bousquet J, Agache I, et al. Allergic Rhinitis and its impact on Asthma (ARIA) guidelines-2016 revision. J Allergy Clin Immunol. 2017;140(4):950–8. https://doi.org/10.1016/j.jaci.2017.03.050. Epub 2017 Jun 8. PMID: 28602936.
4. Cheng L, Chen J, Fu Q, et al. Chinese society of Allergy Guidelines for diagnosis and treatment of allergic Rhinitis. Allergy Asthma Immunol Res. 2018;10:300–53. https://doi.org/10.4168/aair.2018.10.4.300.
5. Wang XD, Zheng M, Lou HF, et al. An increased prevalence of self-reported allergic rhinitis in major chinese cities from 2005 to 2011. Allergy. 2016;71:1170–80. https://doi.org/10.1111/all.12874.
6. Seidman MD, Gurgel RK, Lin SY, et al. Clinical practice guideline: allergic rhinitis. Otolaryngol Head Neck Surg. 2015;152:197–206.
7. Halken S. Prevention of allergic disease in childhood: clinical and epidemiological aspects of primary and secondary allergy prevention. Pediatr Allergy Immunol. 2004;15(Suppl 16):4–59. https://doi.org/10.1111/j.1399-3038.2004.0148b.x. PMID: 15125698.
8. Lee E, Hong SJ. Phenotypes of allergic diseases in children and their application in clinical situations. Korean J Pediatr. 2019;62(9):325–33. https://doi.org/10.3345/kjp.2018.07395. Epub 2019 Apr 23. PMID: 31096745; PMCID: PMC6753312.
9. Hamilton RG, Oppenheimer J, J Allergy Clin Immunol Pract. Serological IgE Analyses in the Diagnostic Algorithm for Allergic Disease. 2015 Nov-Dec;3(6):833 – 40; quiz 841-2. https://doi.org/10.1016/j.jaip.201508.016. Erratum in: J Allergy Clin Immunol Pract. 2016 Mar-Apr;4(2):374. PMID: 26553612.
10. Subspecialty Group of Rhinology, Editorial Board of Chinese Journal of Otorhinolaryngology Head and Neck Surgery. Subspecialty Group of Rhinology and Pediatrics, Society of Otorhinolaryngology Head and Neck surgery, Chinese Medical Association; Editorial Board of Chinese Journal of Pediatrics.

[Guidelines for diagnosis and treatment of pediatric allergic rhinitis (2010, Chongqing)]. Ke Za Zhi. 2011;46(1):7–8. Chinese. PMID: 21429322. Zhonghua Er Bi Yan Hou Tou Jing Wai.

11. Tharpe CA, Kemp SF. Pediatric allergic rhinitis. Immunol Allergy Clin North Am. 2015;35(1):185–98.

12. Kurt E, Metintas S, Basyigit I, Bulut I, Coskun E, Dabak S, Deveci F, Fidan F, Kaynar H, Kunt Uzaslan E, Onbasi K, Ozkurt S, Pasaoglu Karakis G, Sahan S, Sahin U, Oguzulgen K, Yildiz F, Mungan D, Yorgancioglu A, Gemicioglu B, Fuat Kalyoncu A, PARFAIT Study of the Turkish Thoracic Society Asthma and Allergy Working Group. Prevalence and risk factors of allergies in Turkey (PARFAIT): results of a multicentre cross-sectional study in adults. Eur Respir J. 2009;33(4):724–33. https://doi.org/10.1183/09031936.00082207. Epub 2009 Jan 7. PMID: 19129285.

13. Zhang L, Han D, Huang D, Wu Y, Dong Z, Xu G, Kong W, Bachert C. Prevalence of self-reported allergic rhinitis in eleven major cities in china. Int Arch Allergy Immunol. 2009;149(1):47–57. Epub 2008 Nov 26. PMID: 19033732.

14. Sin B, Togias A. Pathophysiology of allergic and nonallergic rhinitis. Proc Am Thorac Soc. 2011;8(1):106–14. https://doi.org/10.1513/pats.201008-057RN. PMID: 21364228.

15. Li J, Wang H, Chen Y, et al. House dust mite sensitization is the main risk factor for the increase in prevalence of wheeze in 13- to 14-year-old schoolchildren in Guangzhou city, China. Clin Exp Allergy. 2013;43:1171–9.

16. Licari A, Ciprandi G, Marseglia A, et al. Current recommendations and emerging options for the treatment of allergic rhinitis. Expert Rev Clin Immunol. 2014;10(10):1337–47. https://doi.org/10.1586/1744666X.2014.955476.

17. Nurmatov U, van Schayck CP, Hurwitz B, et al. House dust mite avoidance measures for perennial allergic rhinitis: an updated Cochrane systematic review[J]. Allergy. 2012;67:158–65.

18. Li Y, Cheng L, Chen X, et al. Efficacy evaluation of a pollen blocker cream against dust-mite allergy: a multicenter, randomized, double-blind, placebo-controlled crossover trial[J]. Am J Rhinol Allergy. 2015;29(5):129–33.

19. Beggs PJ. Impacts of climate change on aeroallergens: past and future. Clin Exp Allergy. 2004;34(10):1507-13. https://doi.org/10.1111/j.1365-2222.2004.02061.x. PMID: 15479264.

20. Wang W, Huang X, Chen Z, Zheng R, Chen Y, Zhang G, Yang Q. Prevalence and trends of sensitisation to aeroallergens in patients with allergic rhinitis in Guangzhou, China: a 10-year retrospective study. BMJ Open. 2016;6(5):e011085. https://doi.org/10.1136/bmjopen-2016-011085. PMID: 27188812; PMCID: PMC4874158.

21. Sun X, Zhao J, Wang Q, Shi G, Yang J, Ming L. Prevalence of allergen sensitization among 15,534 patients with suspected allergic diseases in Henan Province, China. Asian Pac J Allergy Immunol. 2019;37(2):57–64. https://doi.org/10.12932/AP-160817-0137. PMID: 29602285.

22. Ping JD, Zhao JW, Sun XX, Wu F, Jiang ZY, Cheng Z, Zheng L, Xue HK, Yang JJ, Ming L. Prevalence of allergen sensitization among 1,091 patients with urticaria. Exp Ther Med. 2020;19(3):1908–14. https://doi.org/10.3892/etm.2019.8367. Epub 2019 Dec 23. PMID: 32104248; PMCID: PMC7027159.

23. Kynyk JA, Mastronarde JG, McCallister JW. Asthma, the sex difference. Curr Opin Pulm Med. 2011;17(1):6–11. https://doi.org/10.1097/MCP.0b013e3283410038. PMID: 21045697.

24. González-Mendoza T, Bedolla-Barajas M, Bedolla-Pulido TR, Morales-Romero J, Pulido-Guillén NA, Lerma-Partida S, Meza-López C. La prevalencia de rinitis alérgica y dermatitis atópica en adolescentes tardíos difiere de acuerdo con el sexo [The prevalence of allergic rhinitis and atopic dermatitis in late adolescents differs according to their gender]. Rev Alerg Mex. 2019 Apr-Jun;66(2):147–153. Spanish. https://doi.org/10.29262/ram.v66i2.521. PMID: 31200413.

25. Hong SN, Won JY, Nam EC, Kim TS, Ryu YJ, Kwon JW, Lee WH. Clinical manifestations of allergic rhinitis by age and gender: a 12-Year single-center study. Ann Otol Rhinol Laryngol. 2020;129(9):910–7. Epub 2020 May 19. PMID: 32425054.

26. Stemeseder T, Klinglmayr E, Moser S, Lang R, Himly M, Oostingh GJ, Zumbach J, Bathke AC, Hawranek T, Gadermaier G. Influence of intrinsic and lifestyle factors on the development of IgE sensitization. Int Arch Allergy Immunol. 2017;173(2):99–104. Epub 2017 Jun 28. PMID: 28654924.

27. Zahraldin K, Chandra P, Tuffaha A, Ehlayel M. Sensitization to common Allergens among children with asthma and allergic Rhinitis in Qatar. J Asthma Allergy. 2021;14:287–92. https://doi.org/10.2147/JAA.S295228. PMID: 33824594; PMCID: PMC8018446.

28. Yang HJ, Ma XK, Lu JB, Wu GP. [Analysis of allergen spectrum and sensitization factors in children with allergic rhinitis]. Lin Chung Er Bi Yan Hou Tou Jing Wai Ke Za Zhi. 2018;32(21):1636–40. https://doi.org/10.13201/j.issn.1001-1781.2018.21.008. Chinese. PMID: 30400687.

29. Wisniewski JA, Agrawai R, Minnicozzi S. Et a1.Sensitization to food and inhalant allergens in relation to age and wheeze among children with atopic dermatitis[J]. Clin Exp Allergy. 2013;43(10):1160–70.

30. He S, Li YJ, Chen J. Clinical features of allergic rhinitis in children of Shanghai, China. Genet Mol Res. 2016;15(2). https://doi.org/10.4238/gmr.15028118. PMID: 27173334.

31. Fiocchi A, Pecora V, Petersson CJ, Dahdah L, Borres MP, Amengual MJ, Huss-Marp J, Mazzina O, Di Girolamo F. Sensitization pattern to inhalant and food allergens in symptomatic children at first evaluation. Ital J Pediatr. 2015;41:96. https://doi.org/10.1186/s13052-015-0204-9. PMID: 26643320; PMCID: PMC4672564.

Publisher's Note