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ORIGINAL RESEARCH

Aeroallergen Sensitization and Clinical Characteristics of Subjects with Chronic Rhinitis in Chiang Mai, Thailand: A Twenty-Year Retrospective Study

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Background: The prevalence of common aeroallergen sensitization in subjects with AR and clinical comparison between AR and Non-AR (NAR) subjects in Thailand remains limited. The primary objective of this study was to illustrate the prevalence of the common aeroallergen sensitization in AR subjects and the differences in clinical characteristics between AR and NAR subjects.

Methods: Data were retrospectively collected from all subjects with chronic rhinitis who have visited the Chest and Allergy Clinic in three settings in Chiang Mai, Thailand between January 1998 and December 2018. Clinical characteristics and the result of skin prick test (SPT) to common aeroallergen were collected.

Results: A total of 2164 subjects with chronic rhinitis were enrolled, SPT was performed in 1001 (46.3%); 655 (65.4%) and 346 (34.6%) were AR and NAR, respectively. Mite mixed was the most frequent aeroallergen sensitization in subjects with AR both without asthma and with asthma (86.4% and 85.6%) followed by cockroach mixed (54.4% and 58.9%), grass pollen (38.9% and 40.4%), animal dander (15.5% and 19.9%), and mold mixed (5.7% and 11.0%). Polysensitization was higher in younger adults compared to middle aged adult and older adult (72.5%, 67.4%, and 58.7%, respectively, p=0.041). The AR subjects had lower age, earlier age of disease onset, and longer duration of disease (32.6±16.3 vs 40.2±15.4 years, 24 (10–36) vs 34 years (22–45), 3 (1–10) vs 2 years (0–5), respectively, p<0.001). The AR subjects also had more asthma, conjunctivitis, and family history of chronic rhinitis (22.3% vs 15.6%, 25.3% vs 4.3%, and 58.0% vs 43.3%, respectively, p<0.05).

Conclusion: The most common aeroallergen for AR (with and without asthma) was mite mixed followed by cockroach mixed and grass pollen. Polysensitization was significant higher in younger adult than middle aged and older adult. AR was significantly associated with asthma, conjunctivitis and family history of chronic rhinitis compared to NAR.

Keywords: allergy, asthma, rhinitis, allergen, prevalence, skin prick test

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Introduction

Allergic rhinitis (AR) is a common disease, characterized by paroxysms of sneezing, rhinorrhea, and nasal obstruction, often accompanied by itching of the eyes, nose, and palate.[1] The quality of life including sleep, school, work, and social life were affected by AR.[2] The prevalence of AR was reported range from 37.9% to 50.6% in the Asia-Pacific region.[3] In Thailand, the prevalence of AR was reported

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range from 37.7% to 44.2%.[3,4] In Chiang Mai, Pothirat et al reported the prevalence of AR was 43.9%.[5]

The diagnosis of AR tends to rely on the patient's history confirmed by immunoglobulin E (IgE) mediated response via skin prick test (SPT) or serum specific IgE.[6] The SPT is safe, reliable, and recommended as the method of choice to confirm the diagnosis of a specific allergen.[7] The previous studies showed that the prevalence of AR defined by positive SPT range from 9% to 42%.[8,9] The prevalence of aeroallergen sensitization varies in different regions and countries. Cat and cedar pollen were the most common aeroallergen sensitization in Sweden and Japan, respectively.[10,11] But mite was the most common aeroallergen sensitization in Asian countries.[4,12–14] The mite mixed (Dermatophagoides pteronyssinus and Dermatophagoides farina) were the most common aeroallergen sensitization in Chinese and Hong Kong, respectively, [Henan Province (22.8%) and Hong Kong (63.0%)].[9,12] In Thailand, the mite mixed was the most common aeroallergen sensitization (range from 50.1% to 62.2%).[4,13] However, these studies were conducted in Bangkok and Phra Nakhon Si Ayutthaya Province located in central part of Thailand.[4,13] The prevalence of aeroallergen sensitization in the other parts of Thailand remains unknown. Therefore, the primary objective of this study was to illustrate the prevalence of the common aeroallergen sensitization in subjects with AR in Chiang Mai which is located in northern part of Thailand.

The subject with SPT positive was defined as AR and the subject with SPT negative was defined as non-allergic rhinitis (NAR).[15] The previous studies reported that AR subjects had an earlier age of symptom onset, more likely to have a history of asthma, and more severe symptoms associated with itchiness (including itchy nose, sneezing, itchy eye, running nose, and watery eyes).[12,16] However, these comparisons between AR and NAR subjects in Thailand remain unknown. Therefore, the secondary objective of this study was to identify the differences in clinical characteristics between AR and NAR subjects.

Materials and Methods

Data were retrospectively collected from all subjects with chronic rhinitis (symptoms of nasal discharge, congestion, and sneezing for at least 30 minutes daily for 2 or more months). The subjects who visited three settings in Chiang Mai, Thailand (Chest and Allergy clinic in a private clinic, Chiang Mai Ram Hospital, and Sripat Medical Center, respectively) between January 1998 and December 2018 were included. Subjects with other known causes of NAR including occupational rhinitis, aspirin sensitivity, endocrine disease, pregnancy, and drug-induced rhinitis were excluded.

The medical records from electronic database of all subjects were reviewed. The diagnosis of chronic rhinitis including AR and NAR defined by the result of the SPT in all subjects was confirmed by one doctor who specializes in pulmonology and allergy. Clinical characteristics including age, gender, age of disease onset, duration of disease, family history of chronic rhinitis, and comorbidities were collected. The result of SPT to common aeroallergens was also collected. The SPT was performed in subjects who could discontinue antihistamines for at least one week. The standard commercial extract panel (Alk-Abello, Lincoln Diagnostics, Dallas, Tx, USA), included 12 aeroallergens [Mite mixed (Dermatophagoides pteronyssinus (DP) Dermatophagoides farina (DF), cockroach mixed (American, German), Bermuda grass, Timothy grass, Johnson grass, careless weed, animal dander (cat, dog), mold mixed, Aspergillus fumigatus, and Alternaria]. Histamine and normal saline were applied as a positive and negative control, respectively. The AR was defined by the positive result of SPT and the positive result of SPT was defined when the reaction wheal was ≥ 3 millimeters in diameter.[13] The NAR was defined by the negative result of SPT.[15] This study utilized de-identified retrospective medical data. Therefore, this study did not require informed consent. Moreover, the released data are all anonymized and the researchers cannot identify the participants. This study was approved by the Ethics Committee of the Faculty of Medicine, Chiang Mai University (Study code: MED-2562-06437, Date of approval: July 22, 2019) in compliance with the Declaration of Helsinki.

Statistical Analysis

Data are presented as mean ± standard deviation (SD) unless stated otherwise. The prevalence of the common aeroallergen sensitization by SPT of patients with AR was reported in number and proportion. Differences in symptoms and medical history between AR and NAR subjects were analyzed using independent *t*-test and Fisher exact test for continuous data and category data, respectively. Differences in prevalence of aeroallergen sensitization by SPT of patients with AR according to three age groups [<30 year (young adult), 30–50 year (middle aged adult), and >50 years (older adult)] were analyzed using Chi-squared test. Analysis of variance (ANOVA) and

Kruskal–Wallis test were used for comparison parametric data and non-parametric data across three age groups, respectively. Statistical analysis was performed using a software package (StataCorp, College Station, TX, USA).

Results

Study Population

A total of 2164 subjects with chronic rhinitis were enrolled in this study. Nine hundred and seventeen (42.4%) were male with a mean age of 37.8±19.3 years. Asthma was the most common comorbidity (25.6%) in subjects with chronic rhinitis. The SPT was done in 1001 subjects.

Prevalence of Common Aeroallergen Sensitization in Subjects with Allergic Rhinitis without and with Asthma

The SPT was done in 1001 subjects with chronic rhinitis [409 male (40.9%) with a mean aged of 35.2±16.4 years]. SPT positive for at least one allergen was noted in 655 subjects (65.4%). In all AR subjects, the most frequent aeroallergen sensitization that resulted in positive SPT was mite mixed 86.3% followed by cockroach mixed 55.4%, and grass pollen 39.2%, and animal dander 16.5%. Polysensitization was found in 68.4% of subjects (Table 1). The difference of aeroallergen sensitization between AR without asthma and with asthma was mold mixed only (5.7% vs 11.0%, p=0.039) and polysensitization was also significant lower (66.2% vs 76.0%, p=0.026) (Table 1).

Prevalence of Common Aeroallergen Sensitization in Subjects with Allergic Rhinitis (According to Age Group)

The prevalence of SPT positive at least one of allergen was significant higher in younger adult compared to middle aged and older adult (74.7%, 63.1%, and 51.4%, respectively, $p < 0.001$). The cockroaches sensitization was significant higher in younger adults compared to middle aged and older adult (60.2%, 54.8%, and 42.4%, respectively, $p = 0.011$). Polysensitization was also significant higher in younger adults compared to middle aged and older adult (72.5%, 67.4%, and 58.7%, respectively, $p = 0.041$). More data are shown in Table 2.

Comparison of Clinical Characteristics of Subjects with Allergic Rhinitis and Non-Allergic Rhinitis

The clinical characteristics of subjects with AR and NAR are compared in Table 3. The AR subjects had lower age, earlier age of disease onset, longer duration of disease, and were more family history of chronic rhinitis. The AR subjects also had more asthma and conjunctivitis.

Discussion

Our results indicated that SPT positive for at least one aeroallergen was noted in 65.4% of all subjects with chronic rhinitis. These results were comparable with the previous studies in the Asia region including Thailand with a range from 39.9% to 88.9%.[4,5,12,13] The most frequent aeroallergen sensitization was mite mixed (86.3%). The systematic review indicated that the mites were the highest percentage of common aeroallergen sensitization in the Asia region with ranged from 70% to 90%.[14] Our study showed that other aeroallergen sensitization was also found in AR without and with asthma in Chiang Mai, Thailand (cockroach mixed 54.4% and 58.9%, grass pollen 38.9% and 40.4%, animal dander 15.5% and 19.9%, and mold 5.7% and 11.0%, respectively). Similar to the previous systematic review of common causative allergens in allergic rhinitis patients in the Asia region including China, Hong Kong, India, Japan, South Korea, Malaysia, Philippines, Singapore, Taiwan, Vietnam, and Thailand that revealed that cockroach, grass pollen, animal dander, and mold were also found in subjects with chronic rhinitis (cockroach ranged from 5.7% to 59.5%, grass pollen ranged from 2.1% to 75.8%, animal dander ranged from 2.9% to 34.7%, and mold ranged from 1.5% to 42.3%).[14] However, the range of percentages of aeroallergen sensitization found in this systematic review was quite wide. These differences in percentages of aeroallergen sensitization found in each study may be due to many factors including the age of the study sample, study years, geographical and seasonal variations. The first factor is the age of the study sample, previous studies showed that the prevalence of aeroallergen sensitization to mites increased with age.[17,18] Therefore, the differences in age of the study sample resulted in the differences in the prevalence of aeroallergen sensitization. The second factor is the period of study years. For example, the differences in the percentage of aeroallergen sensitization patterns to cockroaches in Singapore (56.4% vs 14.6% in 1999 and 2014,

Table 1 Clinical Characteristics and Skin Prick Test Results of Subjects with Allergic Rhinitis without/with Asthma in Chest and Allergy Clinic from 1998 to 2018

Clinical Characteristics	Allergic Rhinitis		Total (N=655)	p-value
	- Asthma (N= 509)	+ Asthma (N = 146)		
Age (year)	31.4 ± 15.3	36.7 ± 18.7	32.6 ± 16.3	0.001
Male sex	216 (42.4)	64 (43.8)	280 (42.7)	0.777
Age of disease onset (year)	25 (12–35)	20 (6–40)	24 (10–36)	0.206
Duration of disease (year)	2 (0–8)	2 (5–10)	3 (1–10)	<0.001
Family history of chronic rhinitis	281 (55.2)	99 (67.7)	380 (58.0)	0.030
Skin prick test results				
Mite mixed	440 (86.4)	125 (85.6)	565 (86.3)	0.786
Cockroach mixed	277 (54.4)	86 (58.9)	363 (55.4)	0.347
Grass pollen (Johnson, Bermuda, timothy, careless weed)	198 (38.9)	59 (40.4)	257 (39.2)	0.773
Animal dander (Cat, dog)	79 (15.5)	29 (19.9)	108 (16.5)	0.209
Mold mixed (Mold, Aspergillus, Alternaria)	29 (5.7)	16 (11.0)	45 (6.9)	0.039
Type of sensitization				0.026
Monosensitization	172 (33.8)	35 (24.0)	207 (31.6)	
Polysensitization	337 (66.2)	111 (76.0)	448 (68.4)	
Specific immunotherapy (yes)	62 (12.2)	25 (17.1)	87 (13.3)	0.129

Notes: Data are mean ± standard deviation (SD) or n (%), otherwise stated; p-value compared between Allergic Rhinitis without Asthma and Allergic Rhinitis with Asthma.

respectively).[14] Therefore, interval data published at different time points may shift aeroallergen sensitization patterns over time. The last factor is the geographical and seasonal variations. Previous studies indicated that the difference in the prevalence of aeroallergen sensitization was varied across geographical and seasonal variations.[19,20] For mite allergen, the mite allergen level varied across countries and regions primarily based on temperature and humidity.[19] The mite sensitization is very high in Thailand because the country is located in tropical region, the weather usually warm and humid suitable for mite growth.[14]

Our study showed that the mold mixed sensitization was higher in subjects with AR with asthma compared to AR without asthma. Our result was supported by the previous study indicating that odds of asthma prevalence was higher in subjects who allergy for mold (adjusted odds ratio = 15.00).[21] Our study also showed that the polysensitization in AR with asthma subjects was also higher which were supported by the previous study indicating that odds of asthma prevalence was higher in subjects who showed multiple positive allergens (≥2 allergens) (adjusted odds ratio = 12.78).[21]

Our result showed that the cockroach sensitization was significant higher in younger adult compared to middle aged and older adult. Our findings were consistent with the previous study which reported that the higher sensitization rates of cockroaches were in young adults with age 20–40 years old compared to older adults with age ≥55 years old.[22] Polysensitization was also significant highest in younger adult. Our findings were supported by the previous finding which reported that the higher rates of polysensitization in young adults with age <30 years old compared to older adults with age 30–50 years old and >50 years old.[23]

The AR subjects had lower age, earlier age of disease onset, longer duration of disease, more asthma, conjunctivitis, and history of chronic rhinitis compared to the NAR subjects. A previous study also suggested that subjects with AR were more likely to have an earlier age of onset of the disease and were also more likely to be associated with asthma and watery eyes.[12] The European Academy of Allergy and Clinical Immunology (EAACI), and the Allergic Rhinitis and its Impact on Asthma (ARIA) documented that AR is closely related to asthma; both conditions together are often considered to be a single disease affecting the whole respiratory tract.[16]

Previous studies showed the prevalence of allergen sensitization in Thai subjects with AR.[3,4,13] However, this is the first large-scale study to report the prevalence

Table 2 Clinical Characteristics and Skin Prick Test Results of 655 Subjects with Allergic Rhinitis (According to Age Group) in Chest and Allergy Clinic from 1998 to 2018

Clinical Characteristics	Age Group (Year)				p-value
	< 30 (n=284)	30–50 (n=279)	> 50 (n=192)	Total (n=655)	
Age (year)	17.6 ± 7.1	38.7 ± 6.1	60.2 ± 7.0	32.6 ± 16.3	<0.001
Male sex	119 (41.9)	118 (42.3)	43 (46.7)	280 (42.7)	0.703
Age of disease onset (year) (Median, IQR)	12 (5–18)	32 (24–38)	55 (46–60)	24 (10–36)	<0.001
Duration of disease (year) (Median, IQR)	3 (1–7)	3 (1–13)	3 (0–13)	3 (1–10)	0.072
Family history of chronic rhinitis (yes)	199 (70.0)	141 (50.6)	40 (41.3)	380 (58.0)	<0.001
Comorbidity with asthma	50 (17.6)	64 (22.9)	32 (34.8)	146 (22.3)	0.003
Skin prick test results					
Mite mixed	252 (88.7)	238 (85.3)	74 (80.4)	564 (86.1)	0.119
Cockroach mixed	171 (60.2)	153 (54.8)	39 (42.4)	363 (55.4)	0.011
Grass pollen (Johnson, Bermuda, timothy, careless weed)	113 (39.8)	102 (36.6)	42 (46.2)	257 (39.3)	0.259
Animal dander (Cat, dog)	54 (19.0)	44 (15.8)	10 (11.0)	108 (16.5)	0.181
Mold mixed (Mold, Aspergillus, Alternaria)	16 (5.6)	24 (8.6)	5 (5.5)	45 (6.9)	0.324
Type of sensitization					0.041
Monosensitization	78 (27.5)	91 (32.6)	38 (41.3)	207 (31.6)	
Polysensitization	206 (72.5)	188 (67.4)	54 (58.7)	448 (68.4)	

Notes: Data are mean ± standard deviation (SD) or n (%), otherwise stated; p-value for comparison across three age groups.

Table 3 Comparison of Clinical Characteristics of Allergic Rhinitis and Non-Allergic Rhinitis (N=1001)

Clinical Characteristics	Chronic Rhinitis (N=1,001)		p-value
	Allergic Rhinitis (N=655)	Non-Allergic Rhinitis (N=346)	
Age (year)	32.6 ± 16.3	40.2 ± 15.4	<0.001
Male sex	280 (42.7)	129 (37.3)	0.105
Age of disease onset (year) (median, IQR)	24 (10–36)	34 (22–45)	<0.001
Duration of disease (year) (median, IQR)	3 (1–10)	2 (0–5)	0.001
Family history of chronic rhinitis	380 (58.0)	126 (43.3)	<0.001
Comorbidities			
Asthma	146 (22.3)	54 (15.6)	0.013
Allergic conjunctivitis	166 (25.3)	15 (4.3)	<0.001
Atopic dermatitis	65 (9.9)	29 (8.4)	0.494
Chronic rhinosinusitis	50 (7.6)	17 (4.9)	0.111
Nasal polyposis	22 (3.4)	8 (2.3)	0.438

Note: Data are mean ± standard deviation (SD) or n (%), otherwise stated.

of allergen sensitization among subjects with chronic rhinitis in Chiang Mai Province located in northern part of Thailand. These findings of our study may also be applicable in other provinces in the northern part of Thailand which have similar environmental factors including climates, geographical, seasonal variations, and lifestyles to Chiang Mai. However, our study has some limitations. Firstly, many allergens present in the environment, reactivity to only 12 commercialized allergens were tested in our study. Therefore, the difference in tested allergen

sources would also limit the capability to compare with other studies. Secondly, this is a real-world retrospective study. Therefore, further prospective studies should be conducted on a larger scale to determine the incidence and prevalence of allergen sensitization in Chiang Mai or other provinces in the northern part of Thailand. Thirdly, our data were collected in allergy clinic, so naturally the aeroallergen sensitization rates (65.4%) are higher than general population (43.9%).[5] Fourthly, clinical information such as the presence of food allergy was not mentioned in our study. Because our study focused on an aeroallergen sensitization. Therefore, the prevalence of food allergy should be mentioned in the future study. Lastly, the percentage of patients experienced symptoms following contact with specific triggers was not showed in our study. Therefore, this issue should be focused in the future study.

Conclusion

The mite mixed was the most frequent aeroallergen sensitization in subjects with AR without and with asthma followed by cockroach mixed, grass pollen, and animal dander. The AR subjects had lower age, earlier age of disease onset, longer duration of disease, more asthma, conjunctivitis, and family history of chronic rhinitis compared to the NAR subjects. This information may be useful to clinicians for managing subjects with chronic rhinitis.

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Author Contributions

All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the version to be published; and agree to be accountable for all aspects of the work.

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References

1. Wallace DV, Dykewicz MS, Bernstein DI, et al. The diagnosis and management of rhinitis: an updated practice parameter. *J Allergy Clin Immunol*. 2008;122(2 Suppl):S1–84. doi:10.1016/j.jaci.2008.06.003
2. Walker S, Khan-Wasti S, Fletcher M, Cullinan P, Harris J, Sheikh A. Seasonal allergic rhinitis is associated with a detrimental effect on examination performance in United Kingdom teenagers: case-control study. *J Allergy Clin Immunol*. 2007;120:381–387. doi:10.1016/j.jaci.2007.03.034
3. Bunnag C, Jareoncharsri P, Tantilipikorn P, Vichyanond P, Pawankar R. Epidemiology and current status of allergic rhinitis and asthma in Thailand – ARIA Asia-Pacific Workshop report. *Asian Pac J Allergy Immunol*. 2009;27:79–86.
4. Bunjean K, Sukkasem K, Noppacroh N, et al. Prevalence of allergic rhinitis and types of sensitized allergen in adult at Wat Intaram community, Hua Raeu, Phra Nakhon Si Ayutthaya District, Phra Nakhon Si Ayutthaya Province, Thailand. *J Med Assoc Thai*. 2012;95(Suppl 5):S63–68.
5. Chaicharn Pothirat MD, Phetsuk N, Liwsrisakun C, Bumroongkit C, Deesomchok A, Theerakittikul T. Major chronic respiratory diseases in Chiang Mai: prevalence, clinical characteristics, and their correlations. *J Med Assoc Thai*. 2016;99(9):1005–1013.
6. Williams P, Sewell WA, Bunn C, Pumphrey R, Read G, Jolles S. Clinical immunology review series: an approach to the use of the immunology laboratory in the diagnosis of clinical allergy. *Clin Exp Immunol*. 2008;153(1):10–18. doi:10.1111/j.1365-2249.2008.03695.x
7. Bousquet J, Heinzerling L, Bachert C, et al. Practical guide to skin prick tests in allergy to aeroallergens. *Allergy*. 2012;67:18–24. doi:10.1111/j.1398-9995.2011.02728.x
8. Settipane RA, Charnock DR. Epidemiology of rhinitis: allergic and nonallergic. *Clin Allergy Immunol*. 2007;19:23–34.
9. 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. doi:10.12932/AP-160817-0137
10. Ronmark E, Bjerg A, Perzanowski M, Platts-Mills T, Lundbäck B. Major increase in allergic sensitization in schoolchildren from 1996 to 2006 in northern Sweden. *J Allergy Clin Immunol*. 2009;124:357–363. doi:10.1016/j.jaci.2009.05.011
11. Sakashita M, Hirota T, Harada M, et al. Prevalence of allergic rhinitis and sensitization to common aeroallergens in a Japanese population. *Int Arch Allergy Immunol*. 2010;151:255–261. doi:10.1159/000242363
12. Yuen AP, Cheung S, Tang KC, et al. The skin prick test results of 977 patients suffering from chronic rhinitis in Hong Kong. *Hong Kong Med J*. 2007;13(2):131–136.
13. Oncham S, Udomsubpayakul U, Laisuan W. Skin prick test reactivity to aeroallergens in adult allergy clinic in Thailand: a 12-year retrospective study. *Asia Pac Allergy*. 2018;8(2):e17. doi:10.5415/apallergy.2018.8.e17
14. Tham EH, Lee AJ, Bever HV. Aeroallergen sensitization and allergic disease phenotypes in Asia. *Asian Pac J Allergy Immunol*. 2016;34(3):181–189. doi:10.12932/AP0770
15. Seidman MD, Gurgel RK, Lin SY, et al. Clinical practice guideline: allergic rhinitis. *Otolaryngol Head Neck Surg*. 2015;152(1 Suppl):S1–S43. doi:10.1177/0194599814561600
16. Bousquet J, Van Cauwenberge P, Bachert C, et al. Requirements for medications commonly used in the treatment of allergic rhinitis. European Academy of Allergy and Clinical Immunology (EAACI), Allergic Rhinitis and its Impact on Asthma (ARIA). *Allergy*. 2003;58:192–197. doi:10.1034/j.1398-9995.2003.00054.x
17. Yadav A, Naidu R. Clinical manifestation and sensitization of allergic children from Malaysia. *Asia Pac Allergy*. 2015;5:78–83. doi:10.5415/apallergy.2015.5.2.78

18. Li J, Sun B, Huang Y, et al. A multicentre study assessing the prevalence of sensitizations in patients with asthma and/or rhinitis in China. *Allergy*. 2009;64:1083–1092. doi:10.1111/j.1398-9995.2009.01967.x
19. Thomas WR. Geography of house dust mite allergens. *Asian Pac J Allergy Immunol*. 2010;28:211–224.
20. Davies JM. Grass pollen allergens globally: the contribution of sub-tropical grasses to burden of allergic respiratory diseases. *Clin Exp Allergy*. 2014;44:790–801. doi:10.1111/cea.12317
21. Saif NT, Kleiner GI, Forster LQ, et al. Allergies, allergic comorbidities and the home environment in pediatric asthma in Southern Florida. *Int J Environ Res Public Health*. 2021;18(8):4142. doi:10.3390/ijerph18084142
22. Busse PJ, Cohn RD, Salo PM, Zeldin DC. Characteristics of allergic sensitization among asthmatic adults older than 55 years: results from the national health and nutrition examination survey, 2005–2006. *Ann Allergy Asthma Immunol*. 2013;110(4):247–252. doi:10.1016/j.anai.2013.01.016
23. Beutner C, Forkel S, Gupta S, et al. Sex- and age-dependent changes in polysensitization to common aeroallergens over 20 years. *J Asthma Allergy*. 2020;13:725–730. doi:10.2147/JAA.S280771