ORIGINAL ARTICLE

Prevalence of Allergens Sensitization among Children with Allergic Diseases in 10-Years at King Taksin Memorial Hospital

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Objective: To study the prevalence of allergen sensitization patterns in children with allergies and identify the factors associated with allergen sensitization.

Materials and Methods: The medical records of 940 diagnosed patients with allergic diseases aged younger than 15 years were reviewed. Demographic and clinical characteristics were collected. The prevalence of allergic diseases and skin prick test results were recorded. Factors associated with allergen sensitization and the severity of respiratory allergic diseases were determined.

Results: From the 940 patients, 63.2% were boys. Their mean age was 6.13±3.14 years. The allergic patients had asthma in 62.4%, allergic rhinitis in 57%, atopic dermatitis in 17.8%, and food allergies in 11%. The aeroallergens sensitization were *Dermatophagoides pteronyssinus* in 59.6%, *Dermatophagoides farinae* in 57.9%, cockroach in 23.7%, cat pelt in 15.9%, Bermuda grass in 5.8%, and dog epithelium in 5.5%. Mixed shellfish were the most food allergen sensitization at 45.9%, followed by egg white at 19.4%, wheat at 11.2%, and cow's milk at 9.2%. Aeroallergen sensitization significantly impacts the severity of respiratory allergic diseases, particularly severe persistent asthma ($p<0.001$) and moderate to severe allergic rhinitis ($p<0.001$). Environmental exposures, such as pet ownership ($p<0.001$) and the presence of dolls in the bedroom ($p=0.013$), are associated with aeroallergen sensitization.

Conclusion: Aeroallergen sensitization significantly impacts the severity of respiratory allergic diseases. Determining patients' sensitivity to aeroallergens is crucial to guiding allergen avoidance strategies and assessing the risk of developing allergic symptoms.

Keywords: Allergen sensitization; Skin prick test; Thai children; Allergic disease; Allergic severity

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Atopy and allergic diseases have become increasingly prevalent worldwide, significantly impacting public health. Atopy is a genetic predisposition to develop allergic conditions such as asthma, allergic rhinitis, and atopic dermatitis, and is characterized by heightened immune responses to otherwise benign environmental antigens[1]. These conditions result from an exaggerated immune response to typically harmless ecological allergens, leading to inflammation and chronic symptoms[2]. These allergic reactions are mediated by immunoglobulin E (IgE) antibodies, which are produced in response to allergen sensitization, which involves the production of allergen-specific IgE antibodies that bind to high-affinity IgE receptors on mast cells and basophils. Upon subsequent exposure to the same allergen, these cells release mediators such as histamine, leading to the clinical manifestations of allergic diseases[3]. Recent research has elucidated various factors contributing to developing atopy and allergen sensitization, including genetic predispositions, environmental exposures, and microbial influences[4,5].

The testing for IgE sensitization is the diagnostic evaluation of suspected allergic sensitization. Serum allergen-specific IgE antibodies and skin prick tests (SPT) are widely used diagnostic tools for evaluating allergic sensitization. Serum-specific IgE assays against allergens are commonly used in vitro diagnostic approaches. The disadvantage of allergen-specific IgE assay is that it is expensive and requires duration for interpretation[6]. Therefore, SPT is the most frequently used method for detecting

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type I hypersensitivity reactions because it represents the most reliable, rapid, simple, and cost-effective tool for diagnosis[7]. The SPT usually has a positive predictive value ranging from 95% to 100%, along with sensitivity and specificity exceeding 80%[6,7]. However, skin test results must be interpreted by a clinician with adequate knowledge of medical history, clinical findings, and relevant type I allergens[8].

Allergens can be classified by their route of exposure into respiratory allergens as aeroallergens and food allergens. Respiratory allergens can trigger respiratory symptoms such as asthma and allergic rhinitis and are divided into indoor and outdoor allergens[9]. Urbanization can significantly influence allergen sensitization in several ways. In urban areas, higher pollution levels, changes in lifestyle, and reduced exposure to diverse environments can lead to increased sensitization to allergens[10,11]. Regarding allergen sensitization patterns, urban areas often present higher sensitization rates to house dust mites (HDM) and animal dander. At the same time, rural regions may show higher sensitization to pollen and molds[12].

In children with allergies, positive SPT results range from 61.6% to 82.9%[13-15], while in adults, they range from 43.7% to 65.1%[16,17]. Sensitization can also occur without symptoms in about 35.2% of the general population[16]. Common indoor allergens include dust mites, cockroaches, and animal dander, while outdoor allergens include pollen from grasses and molds like *Alternaria* and *Aspergillus*. In Thailand, the most prevalent allergens are HDM, particularly the American (*Dermatophagoides farinae*, Df) and European (*Dermatophagoides pteronyssinus*, Dp) dust mites, followed by cockroaches and cats[13-17]. Previous studies conducted in Thailand have demonstrated relatively consistent patterns of aeroallergen sensitization across different regions. No significant regional differences were observed among allergic patients in Bangkok, the South such as Songkhla Province, and the North such as Chiang Mai Province[13-15]. Similarly, studies conducted in Prapokklao Hospital in the Eastern province of Chanthaburi Province and Surin Hospital, in the Northeastern Surin Province regions also reported comparable sensitization patterns[18,19]. Longitudinal analyses of SPT results, including a study in the South from 2004 to 2009, revealed a significant increase in sensitization to dust mites and cockroaches among asthmatic children[14]. Such trends suggest that environmental factors, including natural disasters like major floods, may influence aeroallergen prevalence over time. For instance, a study of 2,010 pediatric patients with asthma and allergic rhinitis at Siriraj Hospital in 2009 to 2013, showed a decrease in sensitization rates to allergens such as American cockroach, wild grass pollens, and *Cladosporium* spp. following the major flood in Bangkok in 2011[20]. Overall, while regional variations appear minimal, epidemiological data indicate temporal shifts in aeroallergen sensitization patterns. HDM consistently emerge as the predominant aeroallergen nationwide, with cockroach allergens serving as a significant but secondary contributor.

The most important treatments for allergic diseases include patients' education, consistent medication use, identifying risk factors, and avoiding and eliminating allergens[21,22]. Therefore, the present study aimed to describe the allergen sensitization pattern in children with allergies over 10 years and the risk factors associated with the severity of respiratory allergic diseases at King Taksin Memorial Hospital. Allergen avoidances enhance patients' quality of life, reduce complications, and decrease medication use over time, allowing patients to resume normal activities and reduce healthcare costs[21,22].

Objective

The present study aimed to study the prevalence of allergen sensitization patterns in children with allergies over a 10-year period at King Taksin Memorial Hospital, and identify the factors associated with allergen sensitization and the severity of respiratory allergic diseases.

Materials and Methods

Study design and population

A retrospective cross-sectional study was conducted at a Pediatric allergy clinic at King Taksin Memorial Hospital in Bangkok, Thailand, between January 2014 and December 2023. The inclusion criteria were patients newly diagnosed allergic diseases, including asthma, allergic rhinitis with or without allergic conjunctivitis, atopic dermatitis and food allergy in patients aged between 6 months to 15 years at enrollment. Those with symptoms of allergic disease were seen in the pediatric allergy clinic and administered an SPT. The author excluded patients who could not carry out the SPT or had underlying diseases, including other chronic lung diseases, central nervous system diseases, cardiovascular diseases, and other chronic illnesses. The diagnosis of asthma was based on clinical symptoms and the current GINA guideline. According to the GINA guideline, the severity of asthma was classified into mild, moderate, and severe asthma groups[21]. The diagnosis of allergic rhinitis and conjunctivitis was based on Allergic Rhinitis and its Impact on Asthma (ARIA) guidelines[23]. The present study included children diagnosed with asthma, allergic rhinitis, atopic dermatitis, or food allergies. These conditions were analyzed collectively due to their shared pathophysiological basis in IgE-mediated sensitization and their frequent clinical co-occurrence. Subgroup analyses were performed to explore condition-specific patterns where applicable and to assess the severity of respiratory allergic diseases. However, it is important to note that the severity of atopic dermatitis was not assessed.

Skin prick test procedure

The SPT procedures followed the same standardized method consistently applied by pediatric allergists using the Dura Sterile Blood Lancets® devices. The SPT must be performed on healthy skin and is typically applied to the volar surface of the forearm. It was read within 15 to 20 minutes after the procedure. In infants, the back was the preferred site for SPT. Skin tests should not be performed on skin sites with active dermatitis and severe dermographism. Patients did not take any medications that could interfere with the accuracy of the results such as oral antihistamine, systemic corticosteroid, and topical steroid. SPT with common aeroallergens and/or food allergens, including positive and negative controls, were recorded. A mean wheal diameter of 3 mm greater than a negative control was considered an SPT-positive result. SPT for food allergens was performed in patients with a clinical history of suspected food allergies. This included symptoms such as urticaria, angioedema, vomiting, or wheezing temporally associated with food ingestion. Food allergens were not tested in patients presenting solely with respiratory symptoms and no history of food-related reactions.

The allergen extracts (Allertech Co. Ltd., ALK, Abello, New York, USA) use in King Taksin Memorial Hospital, aeroallergens were Dp, Df, mixed cockroach (American cockroach and German cockroach), *Felis catus* (cat pelt), dog epithelium, *Cynodon dactylon* (Bermuda grass), *Brachiaria mutica* (Paragrass), *Amaranthus hybridus* (Careless weed), *Cladosporium sphaerosperium*, and *Alternaria* mix. The food allergens were cow's milk, wheat, egg white, egg yolk, soybean, mixed shellfish such as shrimp, squid, mollusk, and crab, and mixed fish with cod, flounder, and halibut. Histamine phosphate 10 mg/mL and glycerinated phenol-saline were used as positive and negative controls. In the present study, mono-sensitization was defined as a positive SPT result to only one allergen, while poly-sensitization was defined as a positive SPT result to more than one allergen.

Statistical analysis

Demographic and clinical characteristics of participants were summarized using percentage, mean, and standard deviation as appropriate statistical measures to describe data. The prevalence of allergen sensitization was calculated for aeroallergen and food allergen sensitization. An upset plot was used to visualize the mono- and poly-aeroallergen sensitization pattern. Factors associated with SPT aeroallergen sensitization were assessed using a chi-square or Fisher's exact test. In addition, the association between positive SPT and severity of asthma and allergic rhinitis was performed using a chi-square test. A p-value of less than 0.05 was considered statistically significant. The odds ratio (OR) and 95% confidence interval (CI) were calculated using logistic regression. Statistical analysis was performed using R version 4.4.1.

Ethical approval

The present study was approved by the Bangkok Metropolitan Administration Ethics Committee for Human Research (BMAEC-S004hc/67_EXP). This study involved retrospectively reviewing medical records. Informed consent of each participant was not required.

Results

Demographic and clinical characteristics of the patients

One thousand seventeen pediatric patients underwent SPT between January 2014 and December 2023. Of these, 77 were excluded from the study with 69 due to incomplete data, three due to negative in Histamine phosphate control test results, and five due to dermographism. The present study enrolled 940 patients with allergic diseases taking a SPT. The patients' mean ± standard deviation (SD) age was 6.85±3.15 years (range 0.5 to 14.5), and 63.2% were boys. The mean age at first onset of allergic diseases and diagnosis was 4.55±2.71 years and 6.13±3.14 years, respectively. The mean disease duration before diagnosis was 1.58±1.19 years (range 0 to 8) (Table 1). The majority of pediatric allergic

Table 1. Characteristics of patients with allergic diseases

Characteristics	n (%)
Total number; n (%)	940 (100)
Male	594 (63.2)
Female	346 (36.8)
Age (years); mean±SD	6.85±3.15
Range	0.5 to 14.5
Age of diagnosis (years); mean±SD	6.13±3.14
Range	0.5 to 14.3
Age of onset (years); mean±SD	4.55±2.71
Range	0.2 to 13
Duration of disease before diagnosis (years); mean±SD	1.58±1.19
Range	0.0 to 8
Allergic diseases; n (%)	
Asthma	587 (62.4)
Allergic rhinitis (with or without allergic conjunctivitis)	536 (57.0)
Allergic rhinitis with conjunctivitis	225 (23.9)
Atopic dermatitis	167 (17.8)
Co-morbid and risk factor; n (%)	
Food allergy	104 (11.0)
Snoring	292 (31.1)
History of sinusitis	92 (9.7)
History of urticarial rash	89 (9.4)
Family history of atopy	308 (32.8)
Pet owner	253 (26.9)
Environment of tobacco smoke	405 (43.1)
Obesity	156 (16.6)
Doll in bedroom	308 (36.9)
Preterm birth	16 (1.7)
Wheezing associate respiratory tract infection (WARI)	27 (2.8)

SD=standard deviation

patients had asthma at 62.4%, followed by allergic rhinitis with or without allergic conjunctivitis at 57%, atopic dermatitis at 17.8%, and food allergies at 11% (Figure 1). The most common comorbid diseases were snoring at 31.1%, food allergies at 11%, history of sinusitis at 9.7%, and history of urticarial rash at 9.4%. Environmental tobacco smoke, at 43.1%, was the most common factor associated with allergic diseases, followed by a doll in the bedroom, at 36.9%, and a family history of atopy at 32.8% (Table 2). "Doll in bedroom" is defined as the presence of plush or fabric dolls in the child's sleeping environment, which may serve as reservoirs for indoor allergens such as dust mites. Either or, "family history of atopy" is defined a previous physician-diagnosed allergic condition such as asthma, allergic rhinitis, atopic dermatitis, or food allergy, in the first-degree family member. The allergic patients were treated with medication to control and relieve symptoms. Eighty

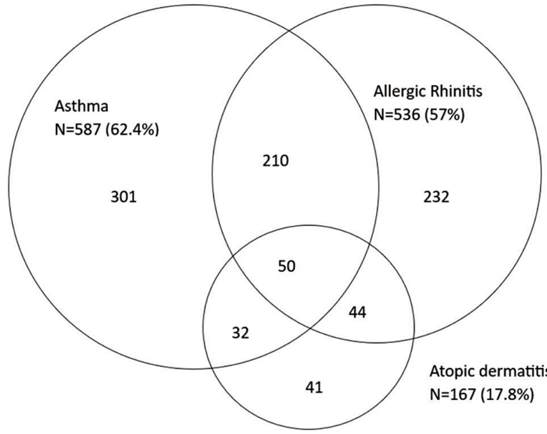

Figure 1. Venn diagrams illustrate the associations among asthma, allergic rhinitis, and atopic dermatitis.

percent of the patients, or 737, used the antihistamine, followed by leukotriene receptor antagonists (LTRA) in 67%, and intranasal steroids in 57%.

Characteristics of asthma patients

Most patients (587) in the present study had asthma with or without allergic rhinitis. Three hundred seventy-seven pediatric patients with asthma were boys, accounting for 64.2%. The severity of asthma was assessed according to the GINA guideline[21]. Among 587 patients, 194 (33%), 291 (49.6%), and 102 (17.4%) patients were defined as having severe, moderate, and mild asthma, respectively. The mean age at diagnosis of asthma was mild 3.69±2.09 years, moderate 4.15±2.5 years, and severe asthma 3.77±2.28 years, respectively ($p=0.08$). About medical history, allergic rhinitis ($p<0.001$), wheezing associated with respiratory illness (WARI) ($p<0.001$), a family history of atopy ($p<0.001$), tobacco smoke environment ($p<0.001$), and history of admission due to lower respiratory tract infection ($p<0.001$) were more significantly likely to be observed in patients with asthma. "WARI" refers to respiratory infections in children that are accompanied by wheezing, commonly associated with viral pathogens, and may be an early indicator of future asthma development[21]. Viral infection data, including influenza, respiratory syncytial virus (RSV), rhinovirus, human metapneumovirus (hMPV), and bocavirus, were collected for a subset of patients; however, these data were not available for all participants and were therefore excluded from the final analysis. Being a pet owner ($p=0.057$), having a doll in the bedroom ($p=0.88$), or having a preterm birth ($p=0.61$) was not associated with

Table 2. Factors associated with SPT aeroallergen sensitization positive

	SPT (aeroallergen); n (%)		p-value
	Positive	Negative	
Total	709	231	
Sex			0.59
Male	452 (76)	142 (24)	
Female	257 (74)	89 (26)	
Asthma			0.26
No	274 (78)	79 (22)	
Yes	435 (74)	152 (26)	
Allergic rhinitis			<0.001
No	275 (68)	129 (32)	
Yes	434 (81)	103 (19)	
Atopic dermatitis			0.002
No	567 (73)	206 (27)	
Yes	142 (85)	25 (15)	
Atopic conjunctivitis			<0.001
No	499 (72)	192 (28)	
Yes	198 (88)	27 (12)	
Food allergy			<0.001
No	614 (73)	222 (27)	
Yes	95 (91)	9 (9)	
History of sinusitis			0.98
No	639 (75)	209 (25)	
Yes	70 (76)	22 (24)	
History of urticaria rash			0.54
No	639 (75)	212 (25)	
Yes	70 (79)	19 (21)	
Snoring			0.23
No	481 (74)	167 (26)	
Yes	228 (78)	64 (22)	
WARI			<0.001
No	701 (77)	212 (23)	
Yes	8 (30)	19 (70)	
History of admission due to lower respiratory tract infection			0.58
No	522 (75)	175 (25)	
Yes	187 (77)	56 (23)	
Pet owner			<0.001
No	487 (71)	200 (29)	
Yes	222 (88)	31 (12)	
Obesity			0.23
No	585 (75)	199 (25)	
Yes	124 (80)	32 (20)	
Doll in the bedroom			0.013
No	431 (73)	162 (27)	
Yes	278 (80)	69 (20)	
Family history of atopy			0.25
No	469 (74)	163 (26)	
Yes	240 (78)	68 (22)	
Preterm birth			0.77
No	696 (75)	228 (24)	
Yes	13 (81)	3 (19)	
Predicted FEV1			0.046
>80%	286 (78)	82 (22)	
79% to 61%	361 (73)	137 (27)	
<60%	62 (84)	12 (16)	

SPT=skin prick test; WARI=wheezing associate of respiratory tract infection; FEV1=forced expiratory volume in one second

asthma at diagnosis. A preterm infant was defined as an infant born between week 28 and week 36 day 6 of gestation[24].

The asthma patients were treated with controller medications, including inhaled corticosteroid (ICS) therapies, which were prescribed to 375 patients (63.9%). Additionally, a combination of fixed-dose ICS and long-acting β-agonist (LABA) was administered to 212 patients (36.1%). Adjunctive therapies included LTRA, prescribed to 451 patients (76.8%), followed by antihistamines to 429 patients (73.1%), intranasal steroids to 249 patients (42.4%), and xanthine to 139 patients (23.7%). The predicted forced expiratory volume in one second (FEV1) in asthma patients was mild in 90.3±14, moderate in 74.8±10.3, and severe persistent in 57±8.3. The mean childhood asthma control test (C-ACT)[25] score at 3-month visit for the 318 controlled was 22.6±3.1, the 230 partly controlled was 19.1±3.1, and the 24 uncontrolled asthma was 18.5±4.2.

Characteristics of rhinitis patients

According to the ARIA guidelines, 536 individuals were identified with rhinitis. Their mean age was 5.38±2.48 years old. There were 342 boys (63.8%) and 194 girls (36.2%). Among them, 67% showed aeroallergen sensitization and were diagnosed with allergic rhinitis. Among the allergic rhinitis patients, 58.8% (315) were classified as having moderate to severe persistent symptoms, while 41.2% (221) had mild persistent symptoms. Predicted FEV1 in rhinitis patients was 88.6±15.6 for the mild and 80.2±16.6 for the moderate to severe. Co-morbid conditions were significantly associated with allergic rhinitis patients, including asthma ($p<0.001$), severe persistent asthma ($p<0.001$), allergic conjunctivitis, sinusitis (p<0.001), snoring (p<0.001), and obesity (p<0.001). Environmental tobacco smoke (p=0.002) was associated with allergic rhinitis, whereas pet ownership (p=0.85) and having dolls in the bedroom (p=0.72) were not significantly associated.

Characteristics of patients with food allergies

SPT for food allergens were performed in 98 out of 104 patients with food allergies. Eighty-four patients with a history of aeroallergen and food allergy underwent SPT for both aeroallergens and food allergens. Among these, food allergen SPT was conducted in only 14 patients, primarily in children under one year of age. The sensitization rate to food allergens was 72.4%. In the present study, patients were categorized based on age groups 16 patients in the 1 year or younger, 29 patients in the 1 to 5 years, and 53 patients in the older than five years. The mean age at the onset of the first diagnosis of food allergy was 0.48±0.17 years, with a range of 3 to 11 months, 1.62±0.98 years, with a range of 1 to 5 years, and 6.64 ± 3.23 years with a range of 6 to 13 years, respectively. Food allergies were commonly associated with atopic dermatitis (42.9%), followed by urticaria (41.8%), allergic rhinitis (35.7%), and asthma (18.9%). Among patients with food allergies, 54.7% also presented with respiratory allergies. This subgroup was predominantly composed of children older than one year. In infants aged younger than 1 year, sensitization rates were highest for cow's milk at 31.2% (p<0.001) and egg white at 31.2% (p=0.085), followed by wheat at 18.8% (p=0.459). Shellfish allergy was significantly more prevalent in children aged older than 5 years at 73.6% (p<0.001). A subset of patients with food allergies in the present study underwent diagnostic evaluations, including open-blind oral food challenges, prick-to-prick skin testing, and specific IgE measurement. However, not all patients completed the full panel of tests, resulting in incomplete data across the cohort. Despite this limitation, the available laboratory findings were consistent with the results of SPT.

Allergen sensitization pattern

Nine hundred twenty-six patients had aeroallergens skin tests, and 98 had food allergens skin tests. Seven hundred nine (75.4%) had positive SPT, 688 out of 926 (74.3%) were positive for aeroallergens, and 71 out of 98 (72.4%) were positive for food allergens. Monosensitization was observed in 333 patients (47%), while polysensitization was

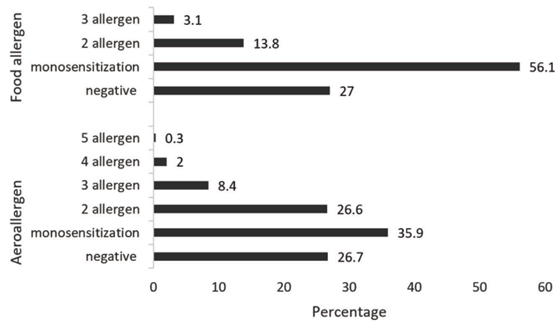

Figure 2. Aeroallergens and food allergens sensitization pattern.

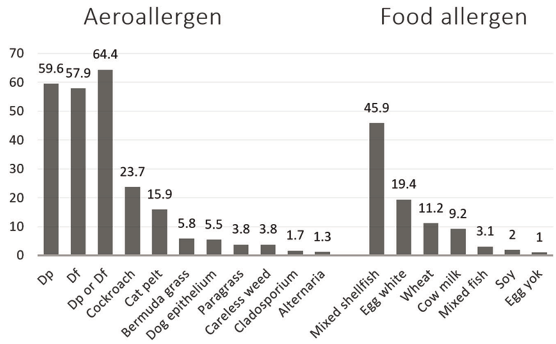

Figure 3. Percentage of aeroallergen and food allergen sensitization.

observed in 376 patients (53%). Allergens sensitization was divided into mono or polysensitization patterns, shown in Figure 2. The most frequent aeroallergens that resulted in positive SPT were Dp at 59.6%, Df at 57.9%, mixed cockroach at 23.7%, cat pelt at 15.9%, Bermuda grass at 5.8%, dog epithelium at 5.5%, and outdoor allergen as in Figure 3. Figure 4a presents the pattern of aeroallergen sensitization among the study population of 926 patients, with allergen groups consolidated to simplify the combinations. Sensitizations were categorized into four main groups, dust mite for Df and Dp, dander for dog epithelium and cat pelt, cockroach for the American cockroach and the German cockroach, and outdoor allergens for the Bermuda grass, Paragrass, Careless weed, *Alternaria*, and *Cladosporium*. The vertical bars represent the number of patients sensitized to specific combinations of these allergen groups, at the intersections, while the horizontal bars indicate the total number of patients sensitized to each allergen group at the unions. The sensitization pattern of aeroallergen sensitization revealed that HDM was the predominant aeroallergen in 267 patients. This was followed by sensitization to a combination of HDM and mixed cockroach for

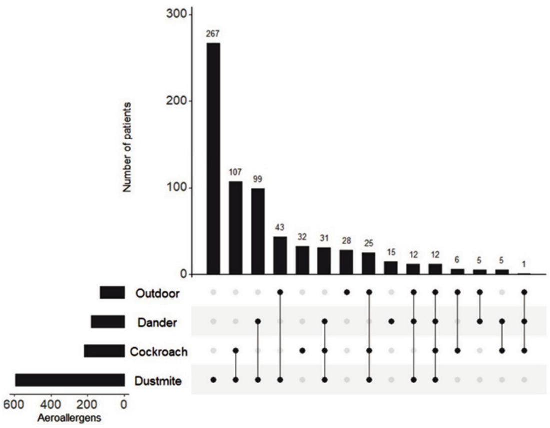

Figure 4a. Pattern of aeroallergen sensitization (n=926). Vertical bars represent the number of patients with positive for each combination of aeroallergen (intersection); horizontal bars represent the number of patients with positive for each aeroallergen (union).

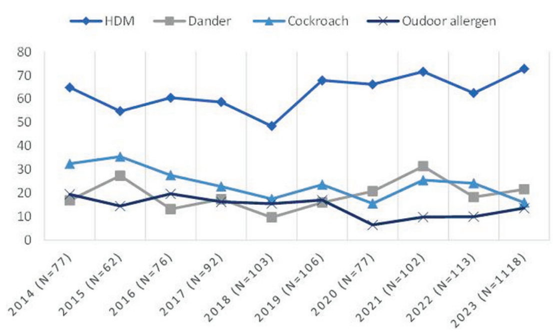

Figure 4b. Pattern of aeroallergen sensitization (n=926) over time.

Dust mite (HDM)=Df, Dp; Dander=Dog epithelium, Cat pelt; Cockroach=American cockroach, German cockroach; Outdoor allergen=Bermuda grass, Paragrass, Careless weed, *Alternaria*, *Cladosporium*

107 patients, and a combination of HDM and animal dander for 99 patients. An analysis of the total number of patients sensitized to each allergen group, whether monosensitized or polysensitized, indicated that HDM were the most common allergens for 596 patients, followed by cockroach allergens for 219 patients and animal dander for 180 patients.

Figure 4b illustrates temporal trends in aeroallergen sensitization among 926 patients from 2014 to 2023. HDM sensitization consistently remained the most prevalent throughout the study period, with rates ranging from 48.5% to 72.8%. Notable peaks occurred in 2020 and 2023, when HDM sensitization exceeded 70%. In contrast, cockroach sensitization demonstrated a gradual decline, decreasing from 32.5% in 2014 to below 20% in recent years. Sensitization to animal dander showed more variability, peaking at 31.4% in 2021, while remaining relatively stable in other years. Sensitization to outdoor allergens remained the least common, displaying a modest downward trend with minimal fluctuation, generally ranging between 6.5% and 19.5%. These findings highlight the persistent predominance of HDM as the leading aeroallergen, with only modest variations observed in sensitization patterns to other allergens over the years. Food allergy testing revealed that mixed shellfish, at 45.9%, were the most common cause of food allergen sensitization, followed by egg white at 19.4%, wheat at 11.2%, and cow's milk at 9.2% (Figure 3). The prevalent monosensitization pattern for aeroallergen and food allergens sensitization are shown in Figure 5. Therefore, the most frequent aeroallergen was HDM, while the most common food allergen was mixed shellfish.

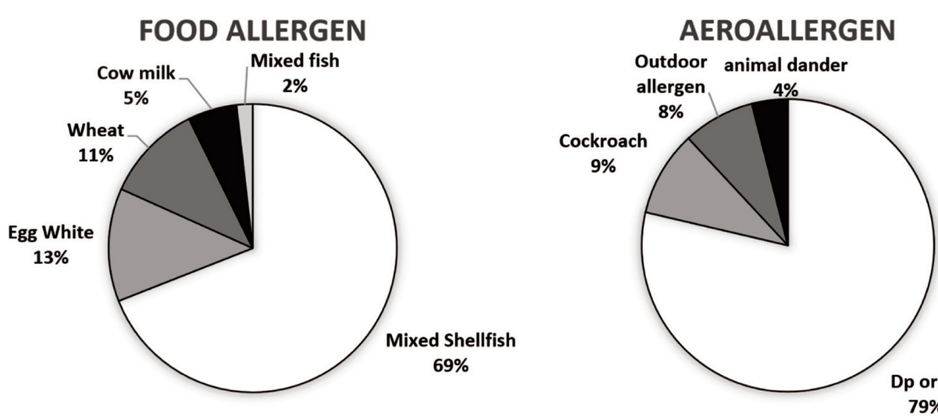

Figure 5. Aeroallergen or food allergen sensitization, only among those with mono-sensitization.

Table 3. Allergen sensitization associated with severity of asthma and allergic rhinitis

Severity	Asthma (n=587); n (%)			Allergic rhinitis (n=536); n (%)	
	Mild	Moderate	Severe	Mild	Moderate to severe
SPT (aeroallergen and food allergen)					
Negative	71 (37)	66 (23)	15 (15)	129 (56)	102 (44)
Positive	123 (63)	225 (77)	87 (85)	275 (39)	434 (61)
p-value		<0.001			<0.001
Aeroallergen sensitization					
Negative	71 (37)	66 (23)	16 (16)	133 (56)	105 (44)
Monosensitization	58 (30)	117 (40)	37 (36)	136 (40)	201 (60)
Polysensitization	65 (33)	107 (37)	49 (48)	121 (35)	230 (65)
p-value		<0.001			<0.001

SPT=skin prick test

Allergen sensitization associated with severity of asthma and allergic rhinitis

A positive aeroallergen SPT was associated with allergic diseases such as allergic rhinitis (p<0.001), atopic conjunctivitis (p<0.001), atopic dermatitis (p=0.002), and food allergies (p<0.001). Allergic diseases were often comorbid, with patients commonly presenting with more than one allergic condition simultaneously. Environmental exposures, such as pet ownership (p<0.001) and the presence of dolls in the bedroom (p=0.013), were associated with aeroallergen sensitization. Children with WARI had a higher rate of negative aeroallergen SPT results compared to other allergic patients (p<0.001) (Table 2). Aeroallergen sensitization significantly impacts the severity of allergic diseases, particularly severe persistent asthma (p<0.001) and moderate to severe allergic rhinitis (p<0.001) (Table 3). There was another essential environmental exposure that affected the severity of allergic diseases was environmental tobacco smoke. Additionally, the present study found a significant association between environmental tobacco smoke and allergic diseases such as asthma (p<0.001) and allergic rhinitis (p=0.002). However, baseline characteristics such as the age of diagnosis, age of onset, and gender were not significantly associated with allergen sensitization and disease severity.

Discussion

The present study found the prevalence of sensitization to at least one allergen among pediatric patients at the Allergy clinic of King Taksin Memorial Hospital in Bangkok was 75.4%. That prevalence is consistent with previous studies in Thailand, which reported rates ranging from 61.6% to 82.9%[13-15]. Although the birth cohorts followed newborns up to the age of four years, it was found that 28.1% of allergic patients and 20.6% of all children showed sensitization to allergens. The proportion of pediatric allergy patients sensitized to allergens was 73.3%[5]. The most prevalent allergens in Thailand are HDM, followed by cockroaches and animal dander. Cat pelt is the most common among animal dander allergens, followed by dog epithelium. Sensitization to outdoor allergens in the Thai population is less common than indoor allergens. However, common outdoor allergens include grass pollen and mold[13-17]. Therefore, allergen selection for SPT was tailored based on clinical suspicion and age-specific exposure patterns. The allergen panels utilized in the present study SPT were selected according to common sensitization profiles reported among Thai pediatric populations, as supported by prior epidemiological data. This targeted and cost-effective diagnostic approach aligns with international guidelines while being adapted to local allergen prevalence patterns.

Moreover, HDM is the most common aeroallergen implicated in allergic individuals in Asian countries. The rates of HDM sensitization were reported in Singapore at 70% to more than 90%, followed by Taiwan at 85% to 90%, India at 63.7% to 89.7%, China at 57.6% to 83.7%, Korea at 49.4% to 72.7%, Philippines at 33.3% to 47.1%, and Vietnam at 9.7% to 13.3%. Sensitization to other aeroallergens was generally lower than HDM across the Asian population. Cockroaches are followed by mold, animal dander, and grass and tree pollen[26]. The aeroallergen sensitization patterns observed in the present study are consistent with those reported in previous studies. The present study was conducted at a single tertiary care center in the urban setting of Bangkok, which may not reflect allergen sensitization patterns in rural or other geographic regions of Thailand. Regional differences in climate, air quality, housing conditions, and environmental exposures such as prevalence of pollen or molds, may contribute to varying patterns of allergen sensitization. Therefore, caution should be exercised when generalizing the study findings to populations in other settings. Multicenter or nationwide studies are warranted to better capture these geographic variations.

Common foods that cause sensitization in Thai children include cow's milk, egg white, and seafood, followed by egg yolk, wheat, soy, and peanuts[27,28]. In allergic Thai children from a tertiary care center, the most commonly sensitized foods for patients aged ≤1 year were egg white and wheat, whereas for those aged >10 years, shrimp was the most common[29]. The present study showed that children aged ≤1 year were sensitized to cow's milk, egg white, and wheat, while children aged >5 years were sensitized to mixed shellfish. The author used a retrospective study approach, which did not determine the specific type of shellfish involved, either serum-specific IgE testing or oral food challenge tests. However, most patients with shellfish allergies had a history of shrimp allergy. Factors associated with parent-reported food allergies include personal and family history of atopic dermatitis[27]. Similarly, the present study found that most food allergy patients also suffered from atopic dermatitis. Unfortunately, the number of patients diagnosed with food allergies in this study was small, and the diagnostic data were incomplete. For future research, prospective studies would be the most appropriate approach to investigate food allergy prevalence and patterns more accurately.

Characteristics of patients with allergic diseases at baseline were also described. Asthma patients were the majority of the present study. Although, boys were atopic more often than girls[5,15]. However, there was no significant difference in sex, age, or age of onset of patients between those positive SPT and those negative SPT. A positive aeroallergen SPT was associated with other allergic diseases, such as allergic rhinitis with or without atopic conjunctivitis ($p<0.001$), atopic dermatitis ($p=0.002$), and food allergy ($p<0.001$). Among patients with food allergy, 84 out of 98 (85.7%) also had concomitant respiratory allergies, suggesting a high co-incidence and an increased likelihood of aeroallergen sensitization. Therefore, environmental factors, such as having pets ($p<0.001$) and dolls in the bedroom ($p=0.013$), were significantly associated with aeroallergen sensitization.

Patients with asthma in the present study were likely to have asthma diagnoses at three to six years old. Approximately one-third of children worldwide are estimated to have been infected with respiratory viruses during their first year of life, including respiratory syncytial or rhinovirus. Infection can increase the risk of recurrent wheezing and childhood asthma[30]. Patients with WARI in the present study exhibited negative results on aeroallergen skin tests, and their wheezing was attributed to respiratory viral infections. Therefore, WARI patients without aeroallergen sensitization may continue to experience wheezing symptoms. Follow-up visits are essential to re-assess their symptoms and re-evaluate allergen sensitization in the future. Providing additional information is crucial to reducing the risk of asthma-related exacerbations and associated comorbidities[21].

Polysensitization was observed in 53% of allergic subjects in the present study. Similarly, previous studies reported rates ranging from 47.2% to 74.3%[31-33]. However, HDM was the most common allergen identified in both mono- and polysensitized subjects in this study. A birth cohort study found that 68.4% of children sensitized to HDM experienced asthma, eczema, and/or rhinitis[5]. In the present study, aeroallergen sensitization was associated with various allergic diseases, including allergic rhinitis ($p<0.001$), atopic conjunctivitis ($p<0.001$), atopic dermatitis ($p=0.002$), and food allergy ($p<0.001$). Polysensitization can lead to higher levels of specific IgE, total IgE, and eosinophils[31]. The severity of allergic symptoms was higher in polysensitized patients than in monosensitized patients[33]. The present study showed a significant relationship between the severity of respiratory allergic diseases and allergen sensitization, particularly severe persistent asthma ($p<0.001$) and moderate to severe allergic rhinitis ($p<0.001$).

Medication was focused on reducing allergic symptoms and minimizing the risk of co-morbidities. However, non-pharmacological strategies are also essential for effectively managing allergic diseases. Education on allergic diseases should improve patients' understanding of disease control, enhance treatment adherence, and promote effective environmental management[21-23]. In the present study, environmental factors such as owning pets, having dolls in the bedroom, and exposure to environmental tobacco smoke were significantly associated with allergic symptoms. Exposure to pet allergens, particularly from cats and dogs, can lead to sensitization and significantly increase the risk of allergic diseases[34]. Although the relationship between pet exposure and the development of allergic sensitization and disease is not entirely understood, the most effective solution for patients allergic to pet allergens is the permanent removal of pets from the household[35].

HDM were Thailand's most essential and prevalent indoor allergens causing sensitization[13-17]. The present study observed an increasing trend in HDM sensitization after 2019, which may be attributed to lifestyle changes during the COVID-19 pandemic, particularly the increased amount of time spent indoors. This trend was accompanied by a decline in sensitization to outdoor allergens, supporting the hypothesis that reduced outdoor exposure and greater indoor confinement may influence allergen sensitization patterns. Sensitivity to dust mite antigens strongly predicts severity and poor control of respiratory allergic diseases[36]. Reducing dust mite allergen exposure in the home can help decrease the severity of asthma, eczema, and allergic rhinitis. The bedroom is significant for implementing dust mite control measures within the home[36-38]. The review article found that a comprehensive approach to reducing exposure to HDM - including education, using encasings, removing carpets and other mite reservoirs, avoiding upholstered furniture and drapes, maintaining humidity below 50%, and vacuuming weekly with a high-efficiency particulate air (HEPA) filter - provides the most significant benefit in minimizing mite exposure[39].

Furthermore, another significant indoor irritant is exposure to active or passive tobacco smoke. A meta-analysis found that, among children and adolescents, both active and passive exposure were associated with a modestly increased risk of allergic diseases. In contrast, passive smoking was explicitly linked to a higher risk of food allergies[40]. The environment of tobacco smoke should be avoided because it has been associated with decreased pulmonary function, increased medication requirements, and increased absence from work in patients with asthma[37,40]. Moreover, implementing environmental modifications can be challenging. Physicians should encourage patients with allergic diseases to adopt simple and cost-effective measures. While avoidance strategies remain a key approach for managing allergies and irritants, they are not consistently supported by robust evidence of effectiveness and remain controversial[39]. Individualized allergen control measures should be part of physicians' comprehensive and holistic approach.

The author used a retrospective cross-sectional study approach, which allowed for the determination of allergen sensitization only in allergic patients without comparison to the general population. The absence of a control group in the study limits the ability to determine whether the observed prevalence of sensitization in allergic patients differs significantly from that in the general population. Although the results of the present study were based on data from a single hospital in Bangkok, the allergy clinic at this hospital is the large pediatric allergy clinic in the city. Patients visiting this clinic represent children living in a large urban area of a developing country. Additionally, all patients in the present study were assessed for allergen sensitization by a pediatric allergist, which likely reduced confounders and biases related to variability in the assessment and treatment of allergic diseases. However, further studies are needed to evaluate allergen sensitization in the general population to better determine the relative risk factors associated with allergic diseases in non-allergic individuals. Future research incorporating both SPT and serum-specific IgE measurements would provide a more comprehensive assessment of allergen sensitization patterns.

Conclusion

All allergic patients should be assessed for their risk of developing allergic diseases, and strategies to reduce disease severity should be implemented. Patients should determine their sensitivity to allergens through skin or in vitro testing for aeroallergens or food allergens[37,38]. Allergy testing can be considered in patients with allergic conditions to assist with allergen avoidance and immunotherapy and to evaluate the risk of developing allergic symptoms[39]. The present study suggested that patient factors, including aeroallergen sensitization, significantly impact the severity of allergic diseases. Therefore, environmental factors such as owning pets, having dolls in the bedroom, and exposure to environmental tobacco smoke were significantly associated with allergic symptoms. Patient education and allergen avoidance are essential for achieving symptom control, maintaining normal activities, minimizing future risks of comorbidities, and improving quality of life.

What is already known about this topic?

Atopy is a genetic predisposition to develop allergic conditions that become increasingly prevalent worldwide. There are various factors contributing to developing atopy and allergy including genetic predisposition, environmental exposures, and microbial influence.

What does this study add?

Aeroallergen sensitization significantly impacts the severity of respiratory allergic diseases. Determining patients' sensitivity to aeroallergens is crucial to guiding allergen avoidance strategies and assessing the risk of developing allergic symptoms.

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Conflicts of interest

The author declares no conflict of interest.

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