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ORIGINAL ARTICLE

Comparable prevalence of aeroallergen sensitization among pediatric patients with allergic respiratory diseases

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Abstract
Introduction: Climate change may influence patterns of allergic sensitization in children.
Objective: To compare the prevalence of aeroallergen sensitization in pediatric patients diagnosed with allergic rhinitis (AR) alone versus those diagnosed with both asthma and AR (asthma/AR).
Methods: A cross-sectional study was conducted at a teaching hospital. Medical records of children aged 2–17 years, diagnosed with AR or asthma between January 2020 and December 2023, and with at least one positive sensitization test, were reviewed. Descriptive statistical analyses were performed for all study variables.
Results: A total of 216 children were included (mean age, 8.4 years; 65.7% male), divided into two groups: AR (107 cases) and asthma/AR (109 cases). Overall, 45 patients (20.8%) were monosensitized, with no significant difference between groups ($p = 0.364$). House dust mites were the most frequent allergens in both groups ($p = 0.992$), followed by cockroach and cat epithelium. Among pollens, oak and ash were the most common, with no significant differences between groups (all $p > 0.05$).
Conclusion: Sensitization to house dust mites predominated in both AR and asthma/AR patients. These findings contribute to current knowledge of the major aeroallergens involved in allergic sensitization among children with respiratory diseases.

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Introduction

Allergic rhinitis (AR) and asthma rank among the most common chronic diseases in childhood. In our country, the Global Asthma Network reports that AR affects 17.9%–24.9% of school-aged children and 26.2%–37.5% of adolescents, whereas asthma prevalence is 5.9% and 8.6%, respectively.[1,2]

In 2020, our country, like many others worldwide, faced an epidemic caused by a novel virus (SARS-CoV-2) that primarily affected the respiratory system.[3] This situation forced populations to remain confined for extended periods, resulting in increased exposure to indoor allergens, which may have elevated the risk of allergic sensitization in children.[4,5] Additionally, the effects of climate change represent another important factor that could significantly influence the rising prevalence of allergic sensitization. Variations in temperature, humidity, carbon dioxide concentration, and rainfall patterns directly affect the production, distribution, and seasonality of environmental allergens, such as pollen and house dust mite.[6,7] These conditions favor greater population exposure to these agents, potentially contributing to the development and exacerbation of allergic diseases, particularly in vulnerable groups such as children.

The frequency of allergic monosensitization is highly variable and depends largely on factors such as geographic location, climate, local vegetation, and patient lifestyle. An important consideration, particularly due to its implications for specific immunotherapy, is determining the proportion of children who are mono or polysensitized. In some regions, monosensitization prevalence is below 5%,[8-11] whereas in others, more than 50% of allergic individuals present monosensitization.[12,13] These variations may also be related to the type of respiratory disease being analyzed.

Sensitization to aeroallergens is a key factor, as it is directly associated with the onset, severity, and persistence of allergic respiratory diseases. This study presents findings on allergic sensitization in children during and after the COVID-19 pandemic, aiming to compare and evaluate the prevalence of aeroallergen sensitization in pediatric patients with AR and those with asthma/AR. The objective is to identify potential common patterns or significant differences between these clinical subgroups, thereby improving the understanding of the behavior of allergic diseases in the context of confinement and environmental changes.

Methods

Setting

The study was carried out at a second-level teaching hospital serving an uninsured population, primarily comprising individuals from low- to middle-income socioeconomic strata residing in western Mexico. Its coverage area notably includes the Guadalajara Metropolitan Area, which comprises eight municipalities and has a population exceeding five million inhabitants.

Study design

This cross-sectional study was conducted through a review of medical records of patients seen between January 2020 and December 2023. Children aged 2–17 years with a recent diagnosis of AR or asthma, at least one positive allergic sensitization test, and residence in Guadalajara, Zapopan, Tlaquepaque, or Tonala were included. Patients with incomplete medical records, diagnoses other than AR or asthma, or without positive sensitization tests were excluded.

Diagnosis of allergic rhinitis and asthma

The diagnosis of AR was made according to the most recent ARIA (Allergic Rhinitis and its Impact on Asthma) guidelines. Following these recommendations, AR is classified as intermittent or persistent based on symptom duration and is further categorized by severity as mild or moderate-to-severe.[14]

In the pediatric population, the diagnosis of asthma was based on a detailed medical history aimed at identifying characteristic symptoms (cough, dyspnea, wheezing) and the clinical response to asthma-specific treatments, since pulmonary function tests can be difficult to perform in young children.[15]

Skin prick test technique and interpretation

Allergens were prepared in a glycerinated solution (1:20 weight/volume) and included a panel of five indoor allergens (house dust mites, cockroaches, and cat and dog epithelia), 11 tree pollens, 8 weed pollens, 6 grass pollens, and 8 airborne fungi. Histamine (positive) and glycerin (negative) were used as controls. Allergic sensitization was assessed via skin prick testing on the children's backs using a standardized lancet (Hollister Stier Laboratories LLC). Reactions were read after 15 minutes, and tests were considered positive if the wheal measured ≥3 mm in diameter compared with the negative control.[16]

Study procedure

Data for the two study groups, one with an exclusive diagnosis of AR and the other with a concurrent diagnosis of asthma/AR, were collected using a structured form specifically designed to review patients' medical records. This instrument captured various variables relevant to the study, including patient age, sex, and the allergic conditions prompting the skin prick tests. Additionally, the results of these tests were recorded in detail.

Statistical analysis

Continuous variables were compared using the Student's t-test or the Mann–Whitney U test, depending on data distribution. Categorical variables were analyzed using the chi-square test or Fisher's exact test, as appropriate. Ninety-five percent confidence intervals (CIs) for proportions were estimated using the Agresti-Coull method. A p-value ≤ 0.05 was considered statistically significant. All analyses were performed using IBM SPSS Statistics version 29.0.2.0 (Armonk, NY, USA).

Ethics

The study was conducted in accordance with the principles of the Declaration of Helsinki. As a retrospective study based on the review of medical records, formal approval from an ethics committee was not required. Nevertheless, the confidentiality of all pediatric patient information was strictly maintained throughout the study.

Results

The analysis included data from 454 children, of whom 216 met the inclusion criteria. The remaining patients were excluded due to negative skin prick tests, residence in cities outside the study area, incomplete information, or the presence of other medical conditions.

In the final sample (n = 216), the mean age was 8.4 ± 3.6 years, and 65.7% of cases were male. No significant differences in age were observed between the AR group and the asthma/AR group (8.7 ± 3.6 vs. 8.1 ± 3.6 years; p = 0.232).

Table 1 presents a detailed comparison of the clinical and demographic characteristics of children diagnosed with AR and those with asthma/AR. Both groups were similar in terms of sex, rhinitis severity, and atopic comorbidities. Regarding age, there was a non-significant predominance of adolescents in the AR group (p = 0.055). The median number of positive skin prick tests was three in each group (p = 0.606).

Notably, 20.8% of patients (45/216; 95% CI: 15.9%-26.8%) were monosensitized. In separate analysis, monosensitization was 23.4% (95% CI: 16.3%-32.3%) in the AR group and 18.3% (95% CI: 12.1%-26.7%) in the asthma/AR group (p = 0.364). The main monosensitizing agents were cockroach (13/45), cat (6/45), oak (4/45), and *Dermatophagoides pteronyssinus* (3/45). Remarkably, cockroach monosensitization was significantly more frequent in the asthma/AR group than in the AR-only group (45.0% vs. 16.0%, p = 0.049) Table 2.

The frequency of allergic monosensitization did not vary by age group (preschool 22.3%, school-aged 16.1%, adolescents 28.6%, p = 0.765), sex (male 21.1% vs. female 20.3%, p = 0.883), or personal history of atopic dermatitis (yes 10.0% vs. no 21.4%, p = 0.692).

Figure 1 shows the proportion of children sensitized to one or more allergens. As observed, the proportion of children sensitized to 10 or more allergens was relatively low.

Figure 2 shows the proportion of allergic sensitization across different aeroallergen groups. Indoor allergens were notably the most frequent, followed by tree allergens, while grass allergens were the least common. Figure 3 presents sensitization findings by allergen category according to whether children had AR alone or in combination with asthma. As in the overall analysis, indoor allergens

Table 1 Characteristics of the study population.

	Total *n* = 216	Allergic diseases		*p*
		Allergic rhinitis *n* = 107	Asthma/Allergic rhinitis n = 109	
Sex, n (%)				0.922
Female	74 (34.7)	37 (34.6)	37 (33.9)	
Male	142 (65.7)	70 (65.4)	72 (66.1)	
Age group, n (%)				0.055
Preschoolers	94 (43.5)	42 (39.3)	52 (47.7)	
School children	87 (40.3)	42 (39.3)	45 (41.3)	
Adolescents	35 (16.2)	23 (21.5)	12 (11.0)	
Severity of allergic rhinitis, n (%)				
Temporal pattern				0.872
Intermittent	90 (41.7)	44 (41.1)	46 (42.2)	
Persistent	126 (58.3)	53 (58.9)	63 (57.8)	
Severity				0.811
Mild	175 (81.0)	86 (80.4)	89 (81.7)	
Moderate-severe	41 (19.0)	21 (19.6)	20 (18.3)	
Comorbidity, n (%)				
Atopic dermatitis	10 (4.6)	7 (6.5)	3 (2.8)	0.212
Oral allergy syndrome	2 (0.9)	1 (0.9)	1 (0.9)	0.999
Positive tests, number, median (P_{25} - P_{75})	3 (2-5)	3 (2-5)	3 (2-5)	0.606
Allergic monosensitization, n (%)	45 (20.8)	25 (23.4)	20 (18.3)	0.364

P-value obtained by the chi-square test, Fisher's exact test, or Mann-Whitney U test.
P25 – P75: 25th percentile – 75th percentile.

Table 2 Frequency of allergens causing monosensitization among children with allergic respiratory diseases.

	Total *n* = 45	Allergic diseases		p
		Allergic rhinitis *n* = 25	Asthma/Allergic rhinitis *n* = 20	
Dermatophagoides farinae	1 (2.2)	0 (0)	1 (5.0)	0.444
Dermatophagoides pteronyssinus	3 (6.7)	3 (12.0)	0 (0)	0.242
Cockroach mix	13 (28.9)	4 (16.0)	9 (45.0)	0.049
Cat	6 (13.3)	4 (16.0)	2 (10.0)	0.678
Taraxacum officinalis	2 (4.4)	1 (4.0)	1 (5.0)	0.999
Phleum pratense	1 (2.2)	1 (4.0)	0 (0)	0.999
Zea mays	1 (2.2)	1 (4.0)	0 (0)	0.999
Fraxinus uhdei	1 (2.2)	1 (4.0)	0 (0)	0.999
Juniperus sp.	1 (2.2)	0 (0)	1 (5.0)	0.444
Platanus occidentalis	1 (2.2)	0 (0)	1 (5.0)	0.444
Prosopis juliflora	2 (4.4)	1 (4.0)	1 (5.0)	0.999
Quercus spp.	4 (8.9)	3 (12.0)	1 (5.0)	0.617
Schinus molle	1 (2.2)	1 (4.0)	0 (0)	0.999
Alternaria alternata	2 (8.0)	2 (8.0)	0 (0)	0.495
Aspergillus fumigatus	1 (2.2)	0 (0)	1 (5.0)	0.444
Candida albicans	1 (2.2)	0 (0)	1 (5.0)	0.444

P-value obtained by the chi-square test or Fisher's exact test.

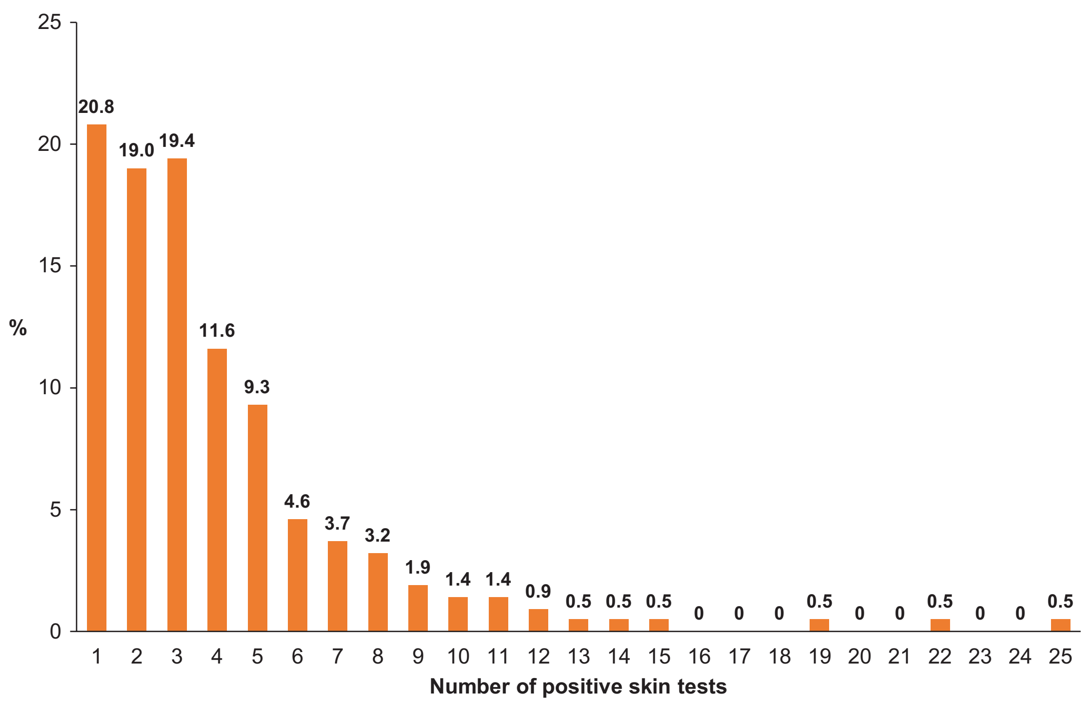

Figure 1 Distribution of allergic sensitization according to the number of allergens.

predominated. In this case, weeds were the least frequent. No statistically significant differences were observed between the groups.

At the individual allergen level, house dust mites were the most frequent sensitizers in children, both in the AR and asthma/AR groups (p = 0.992), while cockroach and cat sensitization ranked second (Table 3). Among tree allergens, oak and ash were the predominant sensitizers, with no significant differences between groups (p > 0.05). For weeds and grasses, dandelion and Timothy grass were the most relevant, respectively. Among fungi, Alternaria was the most significant allergen in both groups.

Discussion

This study analyzed allergic sensitization in 216 children with AR, with or without concomitant asthma, and showed

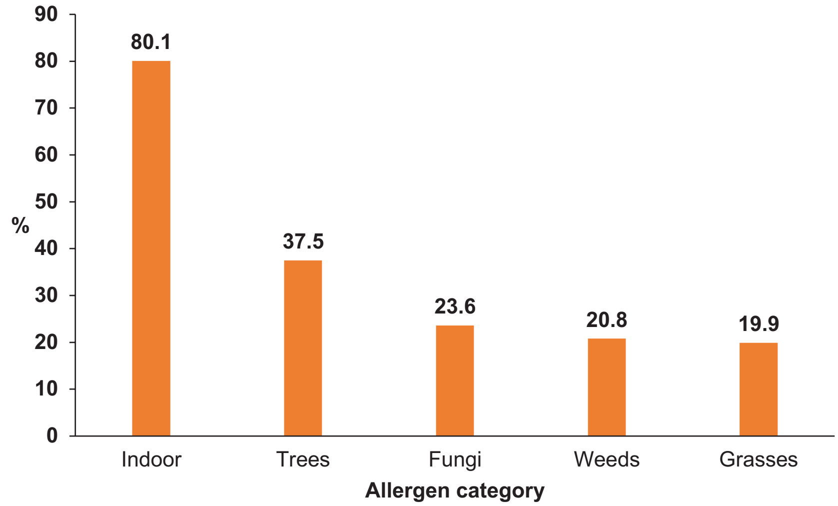

Figure 2 Proportion of allergic sensitization to different groups of aeroallergens; frequencies of sensitization to indoor allergens, trees, grasses, weeds, and fungi are shown in the pediatric population.

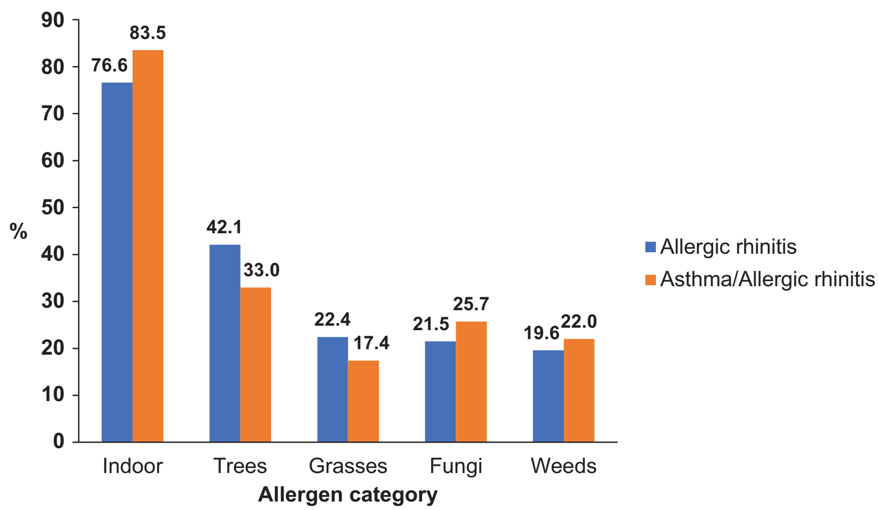

Figure 3 Allergic sensitization by allergen category according to the presence of only allergic rhinitis or in combination with asthma.

that indoor allergens were the most frequent allergens, particularly house dust mites, cockroaches, and cats. Another important finding was that although most children presented polysensitization, 20.8% of them were monosensitized. Cockroaches stood out as the most frequent allergen in this subgroup. Finally, no significant differences were observed between the groups in terms of age, sex, AR severity, number of positive skin prick tests, or the presence of atopic comorbidity, nor in the prevalence of allergic sensitization to any of the allergens tested.

In our study, indoor allergens were the most frequent sensitizers in children, both in the AR-only group and in those with asthma/AR. Among these allergens, the two tested dust mite species were the most prominent, followed by cockroach and cat epithelium. This predominance of house dust mites has also been reported in other studies.[8-11,13,17-20] Although many studies identify dust mites as the main sensitizing agents in children with asthma, some investigations report a higher prevalence of other allergens. For example, in Saudi Arabia, pet dander, particularly from dogs, was the predominant allergen,[21] whereas in Jordan and Israel, pollen, especially olive pollen, was most prevalent.[22,23] In the Saudi study, the authors suggested that increased pet ownership could explain the higher prevalence of sensitization to animal dander, specifically dog epithelium.[21]

Among pollen sensitizations, ash and oak were the most common. Visual inspection of the metropolitan area revealed a high density of ash trees in the central area and surrounding regions, while the nearby forested zone contains abundant oaks and pines. In contrast, in Mexico City, cypress pollen predominated in both children and adults.[20] It is well known that local climate and surrounding vegetation strongly influence pollen dynamics.[24] These two factors help explain why ash and oak were the most prevalent tree allergens causing sensitization in both AR-only children and

Table 3 Prevalence of allergic sensitization according to allergic respiratory disease among the pediatric population.

Allergens	Allergic diseases				p
	Allergic rhinitis n = 107		Asthma/Allergic rhinitis n = 109		
	n	%	n	%	
Indoor					
Dermatophagoides farinae	54	50.5	54	49.5	0.992
Dermatophagoides pteronyssinus	58	54.2	57	52.3	0.778
Cockroach mix	33	30.8	40	36.7	0.363
Cat	28	26.3	38	34.9	0.165
Dog	16	15.0	16	14.7	0.955
Trees					
Acacia sp.	3	2.8	1	0.9	0.367
Alnus spp.	6	5.6	5	4.6	0.767
Fraxinus uhdei	14	13.1	12	11.0	0.639
Juniperus sp.	1	0.9	1	1.8	0.999
Ligustrum spp.	2	1.9	0	0	0.244
Pinus spp.	1	0.9	4	3.7	0.369
Platanus occidentalis	9	8.4	5	4.6	0.254
Populus trichocarpa	7	6.5	6	5.5	0.749
Prosopis juliflora	10	9.3	8	7.3	0.594
Quercus spp.	23	21.5	16	14.7	0.193
Schinus molle	2	1.9	4	3.7	0.683
Weeds					
Amaranthus palmeri	3	2.8	4	3.7	0.999
Ambrosia elatior	3	2.8	1	0.9	0.367
Artemisia vulgaris	6	5.6	2	1.8	0.169
Chenopodium ambrosoides	2	1.9	2	1.8	0.999
Helianthus spp.	3	2.8	7	6.4	0.332
Rumex crispus	4	3.7	5	4.6	0.999
Salsola pestifer	4	3.7	4	3.7	0.999
Taraxacum officinalis	9	8.4	6	5.5	0.401
Grasses					
Avena fatua	2	1.9	2	1.8	0.999
Cynodon dactylon	5	4.7	2	1.8	0.278
Holcus halepensis	3	2.8	2	1.8	0.682
Lolium perenne	5	4.7	3	2.8	0.496
Phleum pratense	15	14.0	14	12.8	0.800
Zea mays	10	9.3	7	6.4	0.425
Fungi					
Alternaria alternata	11	10.3	10	9.2	0.784
Aspergillus fumigatus	8	7.5	10	9.2	0.652
Candida albicans	3	2.8	4	3.7	0.999
Cephalosporium sp.	3	2.8	0	0	0.120
Helminthosporium sp	5	4.7	8	7.3	0.569
Hormodendrum sp.	3	2.8	2	1.8	0.682
Mucor sp.	1	0.9	1	0.9	0.999
Rhizopus sp.	1	0.9	7	6.4	0.065

P-value obtained by the chi-square test or Fisher's exact test.

those with asthma/AR. Regarding cockroach allergens, sensitization was more frequently associated with the asthma/AR group compared to the AR-only group in our study. A recent meta-analysis indicated that cockroach allergy can increase the risk of asthma by more than threefold.[25]

In our study, approximately one-fifth of children with AR or asthma/AR were sensitized to a single allergen. Interestingly, cockroach sensitization was particularly notable in the asthma/AR group. Globally, the frequency of monosensitization varies widely, which may depend on the number of allergens tested, exposure to allergenic sources, and other relevant factors.

In Middle Eastern countries, the prevalence of monosensitization in children has ranged from 15% to 43.1%.[18,21,22] In Asia, it has ranged from 26.2%[17] up to 57.4%.[12] In China, due to its geographical and climatic diversity, different rates of allergic monosensitization have been observed. In the eastern region, one study reported a frequency of 7.7% in children, with no significant differences by age or sex; however, it was higher in children with asthma (16.7%) compared to those with asthma/AR (4.5%) and AR alone (2.8%) ($p < 0.05$).[9] In southern China, a study of more than 21,000 children with AR found a prevalence of 4.5%,[10] contrasting with other studies from the same region: one reported 59% in children with respiratory symptoms,[13] and another found 30.2% in children with AR only and 26.5% in children with asthma ($p = 0.026$).[26] In central China, a study of nearly 12,000 children reported an overall frequency of 3.8%, with similar rates between AR (3.8%) and asthma/AR (3.1%).[11] Finally, another study including more than 4,000 children with AR reported a prevalence of 38.9%.[19] In Mexico, only 2.2% of participants were monosensitized.[8] Some studies have analyzed factors that may influence whether children develop mono- or polysensitization. For example, children with a personal history of atopic dermatitis and total serum IgE levels above 600 IU/mL are more likely to be polysensitized.[21] In our study, no association was found between atopic dermatitis and polysensitization, and IgE levels were not quantified in the children. In summary, the frequency of allergic monosensitization in children with AR or asthma/AR places our population at an intermediate point compared with other studies, with approximately one in five children with allergic diseases being monosensitized.

Although this study did not observe differences in the prevalence of allergic sensitization to aeroallergens between the two groups, contrasting with the hypothesis that AR alone constitutes a distinct respiratory disease from asthma combined with AR,[27] our findings provide valuable insights related to the concept of the unified airway.[28]

Limitations

One of the main limitations of this study is the lack of inclusion of children from other cities within the metropolitan area, as well as those living in rural regions, which may limit the generalizability of the results to the entire pediatric population of the region. It should also be noted that the children received care at a teaching hospital serving an open population without social security coverage, so the results should be interpreted in this context. Additionally, data collection was performed retrospectively from medical records, which carries the risk of incomplete documentation or omissions. This limitation could have led to the exclusion of cases that might have altered or enriched the findings observed.

Conclusions

The results of this study expand knowledge of allergic sensitization patterns in children with allergic respiratory diseases. The findings highlight the importance of indoor allergen sensitization in the pediatric population, with house dust mites, cockroaches, and cat epithelium being the most frequent. The predominance of indoor allergens, potentially associated with housing preservation conditions, provides a favorable context for the implementation of avoidance strategies aimed at improving the control of allergic diseases.

Among outdoor environmental allergens, oak, ash, and Timothy grass pollen were the most prevalent. Additionally, approximately one-fifth of the patients were monosensitized. No significant differences were observed in sensitization patterns between children with AR alone and those with asthma/AR, which further supports the concept of the unified airway.

Author's Contribution

All authors contributed equally to this article.

Conflict of Interest

The authors declare no conflict of interests.

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