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Demographics and clinical features of pediatric patients with allergic rhinitis: a single-center study from Western Turkey

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Abstract

Background Allergic rhinitis (AR) is a disease that has significant effects on the quality of life of people and exhibits different phenotypic features with different clinical findings. By analyzing the data of pediatric patients, we aimed to reveal the relationship between demographic and laboratory data and clinical features and to gain awareness about allergic rhinitis phenotypes in children.

Methods Demographic data, clinical complaints, physical examination findings, and atopy biomarkers are retrospectively analyzed to assess the impact of aeroallergens on the disease phenotype.

Results In a study of 301 AR patients (median age 11 years; 66.1% male), sneezing (79.1%) was the most common complaint, and pallor of the nasal mucosa was the primary examination finding (83.1%). Persistent symptoms were reported by 62.1%, and 60.5% were polysensitized. Notably, 42.5% had asthma, often associated with concurrent sensitization to mold or animal dander ($p \leq 0.05$). Pollen was the most prevalent allergen (65.8%), with significant increases in sensitization to pollen ($p < 0.001$) and animal dander ($p = 0.003$) with age. Patients with pollen sensitization reported more sneezing ($p = 0.026$) and persistent symptoms ($p \leq 0.05$). Nasal congestion was predominantly seen in house dust mite-sensitized patients (78.4% with concha hypertrophy, $p < 0.001$). Overall, it was found that 59.7% of monosensitized patients and 63.7% of polysensitized patients reported persistent complaints.

Conclusion This study, conducted in Western Turkey with 301 allergic rhinitis patients, revealed a high prevalence of polysensitization, particularly to pollen and animal dander. Polysensitized patients were older, exhibited higher IgE levels, and more frequently reported sneezing and rhinorrhea. Furthermore, polysensitization was linked to more persistent and severe symptoms, emphasizing the need for personalized treatment strategies for these patients. Our findings highlight the importance of developing individualized and region-specific approaches to enhance the effectiveness of allergic rhinitis management.

Keywords Asthma, Allergen, Children, Phenotype, Sensitization

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Introduction

Allergic rhinitis (AR), defined as an IgE-mediated inflammation of the nasal mucosa triggered by allergen exposure, is among the most common chronic diseases of childhood [1]. Its prevalence varies regionally. Studies in Western countries have reported a prevalence of 30–40% in the pediatric population, whereas it has been reported with a prevalence of 5–35% in Turkey [1–5]. Although it is not a disease with a poor prognosis, it decreases the quality of life by affecting school success and daily activities in children.

Patients with AR typically present with symptoms including nasal congestion, rhinorrhea, sneezing, and itching. Additionally, some patients may report eye itching as well as a diminished sense of smell and taste. On physical examination, the nasal mucosa is pale and edematous due to inflammation and increased vascular permeability [6]. Allergic shiner, transverse nasal line, and Dennie Morgan lines are among the findings that can be detected on physical examination in children with AR [7, 8].

In addition to history and physical examination findings, the diagnosis of AR is supported by SPT and specific IgE (sIgE) tests, which help to identify possible allergens. SPT continues to be the preferred method for identifying atopy due to its greater sensitivity and lower cost compared with serum-specific IgE. Nonetheless, in pediatric populations and particularly in polysensitized cases, serum-specific IgE may be more appropriate due to its higher specificity [9]. However, these tests only indicate allergen sensitization, and nasal allergen stimulation (NAC) is required to show whether the symptoms are directly attributable to the suspected allergen [10]. Most centers follow a diagnostic approach based solely on SPT and serum allergen sIgE, and NAC cannot be performed because it is difficult, time-consuming, and requires equipment.

Classification of rhinitis entities according to phenotypes has facilitated their characterization and helped practicing clinicians to approach rhinitis patients effectively. On the other hand, these phenotypic features may sometimes overlap and sometimes even transform into each other, thus complicating treatment and management. Currently, three different allergic phenotypes of rhinitis are recognized: AR, local allergic rhinitis (LAR), and dual allergic rhinitis (DAR) [11]. In this context, a detailed clinical history, comprehensive examination findings, and thorough laboratory evaluations are essential for guiding appropriate management and tailoring treatment strategies to each patient's specific phenotype.

The classification outlined in the latest Allergic Rhinitis and its Impact on Asthma (ARIA) report, based on symptom duration and disease severity, serves as the foundation for phenotyping AR. Previously classified as seasonal or perennial based on symptom duration, allergic rhinitis is now designated as intermittent if symptoms occur less than four days per week or four weeks per year and as persistent otherwise. Patients are further categorized as mild or moderate-severe according to clinical severity, using verbal descriptive scales [12]. In particular, perennial triggers typically include house dust mites, mold, and animal hair, whereas tree and grass pollens occurring in specific seasons primarily cause seasonal symptoms [13, 14]. Some patients may experience seasonal exacerbations in addition to year-round symptoms. Moreover, due to changing climatic conditions, it has also been observed that seasonal allergens can lead to perennial manifestations, while perennial allergens may induce seasonal symptoms. Consequently, this approach is considered to enhance disease management and more accurately reflect the relationship between AR and asthma.

Patients with AR are classified into two groups based on their sensitization patterns: monosensitized or polysensitized. While some AR patients are monosensitized, often primarily to pollen, approximately 70% (20%-90%) are polysensitized. In the polysensitized group, symptoms tend to be more severe, asthma is more prevalent, and serum total IgE levels are elevated [15–19].

This study aimed to analyze data from pediatric patients with allergic rhinitis at a tertiary care pediatric allergy clinic in western Turkey, in order to describe sensitization patterns to common allergens and their associations with age, gender, laboratory findings, and clinical symptoms.

Materials and methods

Study design

From January 2020 to January 2023, patients diagnosed with allergic rhinitis AR and having a positive skin prick test (SPT) were included in the study, with data analyzed retrospectively.

Inclusion criteria

Patients aged 2–18 years diagnosed with AR according to ARIA criteria were included in the study.

Exclusion criteria

Cases with signs of respiratory tract infection at the time of diagnosis and cases with missing retrospective data were excluded from the study.

Demographic and clinical data

The age, gender, presenting complaints, characteristics of the symptom period, physical examination findings, laboratory results (including serum total IgE, skin prick test (SPT), and absolute eosinophil count (AEC)), as well as comorbidities of the patients included in the study were retrospectively analyzed and documented in the case report form.

Atopy evaluation

The SPT results for all 301 patients included in the study were evaluated. An allergy was considered significant if there was an induration of 3 mm or more compared to the negative control (saline), in conjunction with the patient's symptoms. Pollen (*Poaceae*, *Artemisia vulgaris*, *Betula alba*, *Olea europaea*, *Fagus sylvatica*, *Alnus glutinosa*, *Phleum*, *Parietaria*, and a grass mix containing *Lolium perenne* (Ryegrass), *Phleum pratense* (Timothy grass), *Cynodon dactylon* (Bermuda grass), and *Festuca* (Fescue grass)), house dust mite (Dermatophagoides pteronysinus, Dermatophagoides farinae), animal dander (Felis domesticus, Canis familiaris) and mold (Alternaria alternata, Aspergillus fumigatus) allergens were used in SPT (Lofarma S. p.A., Milan, Italy). Results were standardized and interpreted according to the methods of AAS and Belin [20]. Patients with sensitization to two or more allergens were considered polysensitised if clinically compatible.

Statistical analysis

At the end of the data collection process, SPSS version 29 software was used for statistical analyses and the limit of statistical significance was set as $p \leq 0.05$. Distributions of variables and correlations were analyzed and statistically significant results were highlighted. The conformity of the variables to normal distribution was analyzed by visual (histogram and probability graphs) and analytical methods (Kolmogorov–Smirnov). Independent samples T-test and ANOVA were used for the evaluation of normally distributed variables, and Wilcoxon and Mann Whitney U test were used for variables that did not show normal distribution.

Results

A total of 301 patients with AR were evaluated. The median age of the patients was 11 years (min–max: 3–17 years); the majority of the patients were male ($n=199$, 66.1%). The most common presenting complaint was sneezing ($n=238$, 79.1%) and the most common physical examination finding was pallor of the nasal mucosa ($n=250$, 83.1%). Persistent complaints were frequently present ($n=187$, 62.1%) and most of the patients were polysensitised ($n=182$, 60.5%). When the presence of comorbidity was evaluated, it was observed that about half of the patients ($n=128$, 42.5%) had asthma, followed by chronic urticaria ($n=18$, 6%), atopic dermatitis (AD) (4.3%), and food allergy ($n=4$, 1.3%). Most of the patients received nasal corticosteroids (NCS) for rhinitis ($n=281$, 93.4%); the other treatment distributions were locotriene receptor antagonists (LTRA) ($n=100$, 33.2%), oral antihistamines (OAH) ($n=80$, 26.6%) and nasal antihistamines (NAH) ($n=11$, 3.7%) (Table 1).

Table 1 Basic characteristics of the patients

Study group ($n=301$)	
Age (years) (med, min–max)	11 (3–17)
Gender: n (%)	K:102 (33.9%) E:199 (66.1%)
Total IgE[a] (IU/mL) (med, min–max)	234 (8.95–3035)
AEC[b] (med, min–max)	300 (0–2900)
Complaint (n, %)	
Nasal congestion	234 (77.7%)
Rhinorrhea	215 (71.4%)
Nasal itching	235 (78.1%)
Sneezing	**238 (79.1%)**
Physical Examination findings (n, %)	
Concha hypertrophy	209 (69.4%)
Nasal pallor	**250 (83.1%)**
Conjunctivitis	157 (52.2%)
Allergic shiner	110 (36.5%)
Transverse nasal line	59 (19.6%)
Dennie morgan line	36 (12%)
Duration (n, %)	
Intermittent	114 (37.9%)
Persistent	**187 (62.1%)**
Severity (n, %)	
Mild	143 (47.5%)
Moderate-severe	**158 (52.5%)**
Sensitisation (n, %)	
Monosensitised	119 (39.5%)
Polysensitised	**182 (60.5%)**
Comorbidities (n, %)	
Asthma	**128 (42.5%)**
AD[c]	13 (4.3%)
Chronic urticaria	18 (6%)
Food allergy	4 (1.3%)
Medications (n, %)	
NCS[e]	**281 (93.4%)**
NAH[f]	11 (3.7%)
LTRA[g]	**100 (33.2%)**
Oral antihistamines (OAH)	**80 (26.6%)**
Ocular antihistamines (OcAH)	7 (2.3%)
Inhaled corticoteroids (ICS)	128 (42.5%)

[a] IgE: Immunoglobulin E'

[b] AEC: Absolute eosinophil count

[d] AD: Atopic dermatitis

[e] NCS: Nasal corticosteroids

[f] Nasal antihistamines

[g] Leukotriene receptor antagonists

When the distribution of allergen sensitization was analyzed, pollen sensitization was the most common ($n=198$, 65.8%), followed by animal dander ($n=142$, 47.2%), house dust mite ($n=116$, 38.5%), and mold ($n=51$, 16.9%). Among polysensitized cases, most of the patients ($n=100$, 54.9%) had coexistence of pollen and animal dander sensitization, 50 (27.4%) had pollen and house dust mite, 40 (13.3%) had animal dander and house dust mite, 35 (11.6%) had mold and pollen, and 18 (6%) had mold and house dust mite sensitization (Fig. 1).

There were no significant differences in the prevalence of asthma among monosensitized patients with respect to the sensitizing allergen profile. However, among the polysensitized groups, the frequency of asthma was significantly higher in patients with concurrent sensitization to either mold or animal dander ($p \leq 0.05$).

Analysis of allergen sensitization distribution by age revealed a significant increase in sensitization to pollen ($p<0.001$) and animal dander ($p=0.003$) with advancing age among our patients with AR (Fig. 2). Patients with pollen sensitization were more likely to report persistent symptoms ($p \leq 0.05$) and complain of sneezing ($p=0.026$) compared to others. Additionally, patients with transverse nasal lines more frequently reported rhinorrhea, sneezing, and itching, while nasal congestion was more commonly observed in patients with Dennie-Morgan lines ($p \leq 0.05$).

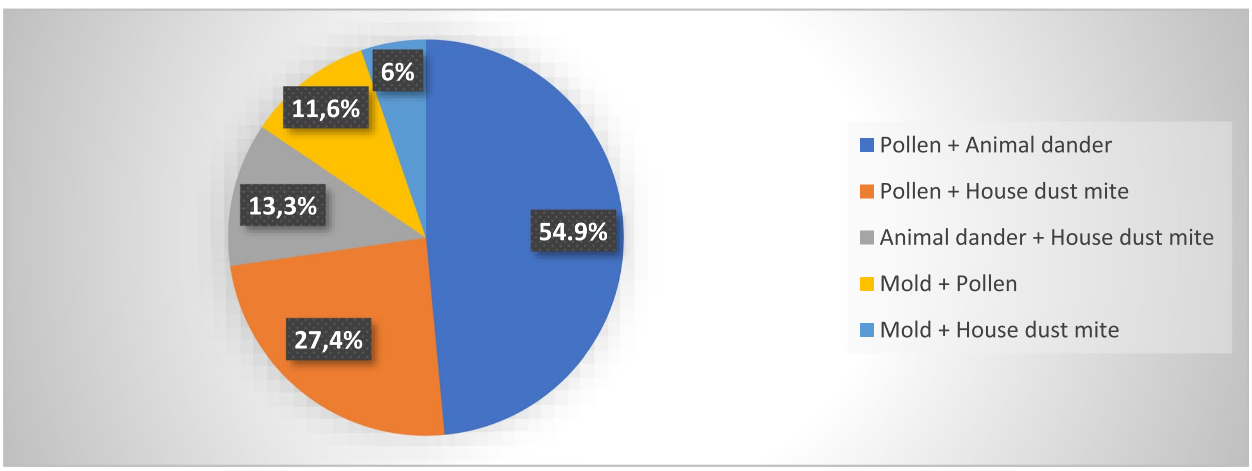

Fig. 1 Allergen distribution of polysensitised subjects

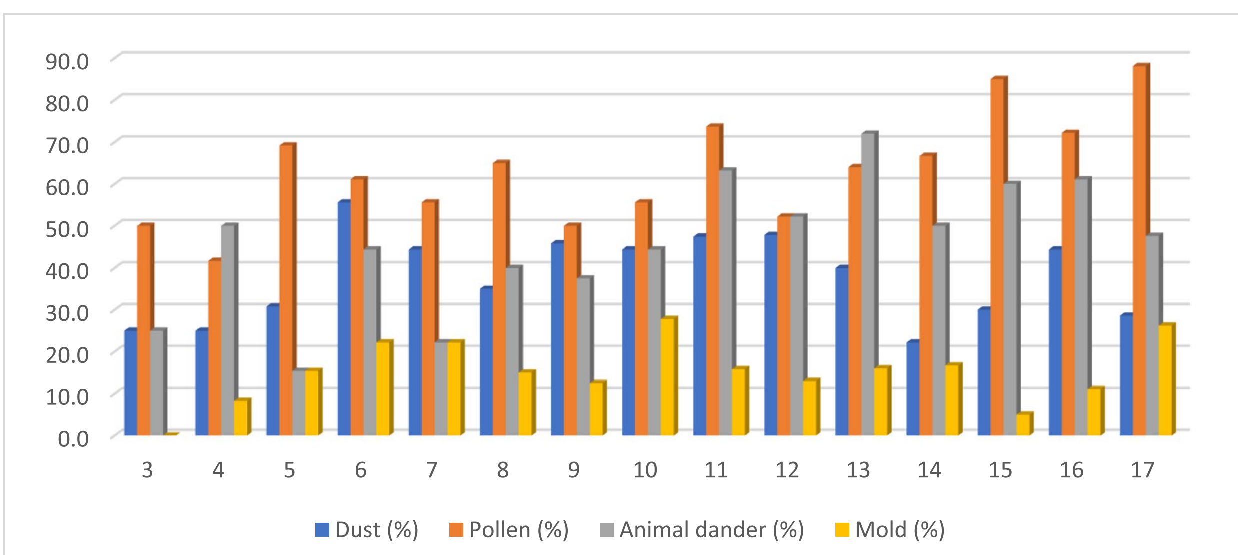

Fig. 2 Allergen sensitisation by age

Nasal congestion was most prevalent among patients sensitized to house dust mites, with the majority of these patients ($n=91$, 78.4%) exhibiting concha hypertrophy ($p<0.001$) (Table 2). Rhinorrhea, sneezing, and itching were more frequently reported in patients with conjunctivitis compared to those without ($p\leq0.05$). Analysis of physical examination findings by age revealed that conjunctivitis was more common in older age groups ($p=0.012$), while shiner findings were more prevalent in younger age groups ($p=0.002$).

The relationship between asthma presence and rhinitis findings showed that the frequency of asthma increased with age, though this association was only marginally significant ($p=0.054$). Additionally, nasal pallor was more frequently observed in patients with asthma compared to those without ($p\leq0.05$). On the other hand, there were no differences in terms of gender, symptoms, sensitization, and laboratory data between patients with and without asthma.

When evaluating the severity of manifestations among our patients, 158 individuals (52.5%) exhibited moderate-severe symptoms; 82% of these patients were polysensitized ($p<0.001$). Female patients were more likely to have moderate-severe symptoms (64%), whereas male patients more frequently presented in mild group (53%) ($p<0.05$). The majority of the moderate-severe group were sensitized to pollen (82%) and animal dander (59%) ($p<0.05$). These patients more frequently reported persistent symptoms (73.4%), whereas those with mild symptoms were more likely to experience intermittent symptoms (50.3%) ($p<0.001$). No significant association was observed between the severity of manifestations and clinical or laboratory findings. However, younger patients (median age: 9 years; range: 3–17 years) were more likely to report mild symptoms, while older patients (median age: 13 years; range: 4–17 years) more frequently exhibited moderate-severe ($p<0.05$).

It was observed that the majority of patients ($n=187$, 62.1%) reported persistent complaints, with a higher frequency noted in polysensitized patients compared to monosensitized patients (63.7% vs. 59.7%, $p>0.05$). In the monosensitized group, patients with sensitization to house dust mites ($n=89$, 76.7%), mold ($n=40$, 78.4%), and animal dander ($n=101$, 71.1%) predominantly had persistent symptoms ($p\leq0.05$). On the other hand, a lower frequency of persistent symptoms was observed in the monosensitized group with pollen sensitivity ($n=107$, 54%). Among pollen-sensitive patients, the most frequent sensitization was to *Olea europaea* ($n=124$, 44.3%). This was followed by sensitizations

Table 2 Characteristics of sensitivity groups

	Pollen sensitisation	**House dust mite sensitisation**	**Animal dander sensitisation**	**Mold sensitisation**	***Total***	***p***
Age (med, min–max)	12 (3–17)	11 (3–17)	12 (3–17)	11 (3–17)	11 (3–17)	> 0.05
Gender %						
F:	32.3	31	39.4	35.3	33.9	> 0.05
M:	67.7	69	60.6	64.7	66.1	> 0.05
Complaint (%)						
Rhinorrhea	74.2	67.2	71.8	72.5	71.4	> 0.05
Nasal congestion	77.3	79.3	74.6	76.5	77.7	> 0.05
Itching	80.3	75	78.9	82.4	78.1	> 0.05
Sneezing	**82.8**	76.7	80.4	83.1	79.1	≤ **0.05**
Physical examination findings (%)						
Concha hypertrophy	68.7	**78.4**	65.5	74.5	69.4	≤ **0.05**
Nasal pallor	85.4	82.8	83.8	78.4	83.1	> 0.05
Shiner	37.9	34.5	33.8	37.3	36.5	> 0.05
Conjunctivitis	54	51.7	52.1	58.8	52.2	> 0.05
Transverse nasal line	21.7	15.5	23.2	15.7	19.6	> 0.05
Dennie Morgan	10.6	10.3	14.1	9.8	12	> 0.05
Asthma (%)	42.4	47.4	40.1	52.9	42.5	> 0.05
T. IgE[a] (IU/mL) (med, min–max)	245 (8.95–3035)	**301 (16.5–2708)**	263.5 (11.3–3035)	213 (9.3–2400)	234 (8.95–3035)	> 0.05
AEC[b] (med, min–max)	300 (0–1800)	**400 (0–2100)**	300 (0–2900)	300 (100–1100)	300 (0–2900)	> 0.05

[a] T. IgE: Total immunoglobulin E

[b] AEC: Absolute eosinophil count

to grasses ($n=72$, 25.7%), *Parietaria officinalis* ($n=32$, 12%), *Phleum* ($n=28$, 10%), and *Betula alba* ($n=12$, 4.4%).

Analysis of mono- and polysensitized patients revealed that the rate of polysensitization increased with age ($p=0.009$). Additionally, the group with predominant rhinorrhea ($n=117$, 64.7%) and sneezing ($n=116$, 63.9%) was more frequently polysensitized ($p\leq0.05$). Polysensitized patients reported more intense symptoms, and asthma was more commonly associated with polysensitization compared to monosensitization, although this relationship was not statistically significant ($p>0.05$). Total IgE levels were higher in the polysensitized group ($p=0.001$), while AEC was not significantly different ($p>0.05$) (Table 3).

Discussion

This study provides a comprehensive examination of pediatric patients with AR, highlighting the most frequently reported symptoms, such as sneezing and nasal itching, along with predominant physical findings, including nasal pallor and turbinate hypertrophy. Notably, the majority of patients in our cohort had pollen sensitivity, with polysensitization and persistent symptoms being more predominant.

AR, one of the most prevalent chronic diseases globally, is characterized by classic symptoms—frequent sneezing, rhinorrhea, and nasal congestion—often accompanied by ocular manifestations [21]. The pathophysiological mechanisms involve the activation of mast cells and basophils upon allergen exposure, leading to the release of mediators such as histamine, increased vascular permeability, and tissue edema. Our findings corroborate existing literature regarding nasal pallor as an important clinical sign, which has been associated with reduced airflow and eosinophilic infiltration [22, 23]. Additionally, transverse nasal lines and Dennie-Morgan lines were identified as significant, albeit less common, indicators of chronic allergic reactions, reinforcing previous findings on their diagnostic relevance [24, 25].

The rising prevalence of pollen sensitization, exacerbated by climate change, underlines the importance of recognizing pollen as a primary trigger for AR symptoms [26, 27]. Our study contributes to this discourse

Table 3 Comparison of monosensitised and polysensitised group

	Monosensitised (*n* = 119)	**Polysensitised (*n* = 182)**	***p***
Age (med, min–max)	9 (3–17)	**12 (3–17)**	≤ **0.05**
T. IgE[a] (IU/mL) (med, min–max)	167 (11.2–2400)	**276 (8.95–3035)**	≤ **0.05**
AEC[b] (med, min–max)	300 (0–2100)	300 (0–2900)	> 0.05
Asthma frequency (%)	38.7	45.1	> 0.05
Complaint (%)			
Rhinorrhea	35.3	**64.7**	≤ **0.05**
Nasal congestion	42.7	58.5	> 0.05
Itching	37.4	62.6	> 0.05
Sneezing	36.6	**63.9**	≤ **0.05**
Findings (%)			
Concha hypertrophy	40.2	59.8	> 0.05
Nasal pallor	38.4	61.6	> 0.05
Conjunctivitis	33.8	**66.2**	≤ **0.05**
Shiner	38.2	61.8	> 0.05
Transverse nasal line	28.8	71.2	> 0.05
Dennie Morgan	38.9	61.1	> 0.05
Duration (%)			
Persistent	59.7	63.7	> 0.05
Intermittent	40.3	36.3	> 0.05
Severity			
Mild	**76.5**	28.6	**< 0.001**
Moderate-severe	23.5	**71.4**	**< 0.001**
Number of findings (med, min–max)	2 (0–6)	3(0–6)	> 0.05
Number of complaints (med, min–max)	3 (1–4)	3 (1–4)	> 0.05

[a] T. IgE: Total immunoglobulin E

[b] AEC: Absolute eosinophil count

by demonstrating that older, pollen-sensitized patients exhibit increased symptoms, suggesting that the ability to articulate symptoms improves with age and sensitization.

In our study, the relationship between prolonged exposure to environmental allergens and chronic nasal changes was further emphasized, with conchal hypertrophy significantly higher among patients sensitized to house dust mites and mold fungi year-round [28, 29]. This finding enhances our understanding of how sustained allergen exposure contributes to the pathophysiology of AR in the pediatric population. Additionally, our ecological analysis investigating the relationship between pediatric asthma emergency visits and air pollutants revealed that increased levels of irritant gases, such as nitrogen monoxide (NO) are associated with a rise in asthma exacerbations [30]. These findings collectively highlight the multifaceted impact of environmental factors on respiratory health in children, indicating that both allergen exposure and air pollution play critical roles in the prevalence and severity of respiratory diseases like AR and asthma. Consequently, comprehensive management strategies that address both allergen exposure and air pollution are essential for effectively reducing the burden of allergic and respiratory diseases in the pediatric population.

In a review emphasizing the impacts of climate change on pollen production and the variability of these effects across different plant species and geographic regions, distinct increasing and decreasing trends were observed in the Annual Pollen Integral (APIn) measurements for various pollen types at the beginning and end of the studies, attributable to global warming [31]. Understanding the environmental context is crucial, as Turkey's diverse geography—bordered by seas on three sides and featuring plateaus that rise towards the east—contributes to varied microclimates affecting allergen exposure. The country is divided into five main regions—Western, Eastern, Southern, Northern, and Central—each with distinct characteristics. The Western region, where our clinic is located, is influenced by the typical Mediterranean climate and features predominantly maquis vegetation, similar to Southern Europe and Mediterranean countries. This region is largely dominated by species from the *Cupressus* and *Pinaceae* families, as well as short trees such as *Fraxinus, Scorzonera, Oleacea*, and *Quercus*. Herbaceous plants like ground basil, nettle-stinging herbs, and nervewort are also prevalent. These regional variations contribute to the differential trends in pollen production and allergen profiles underscoring the necessity for region-specific strategies in managing allergic diseases in the context of ongoing climate change.

In this context, recent studies have shed light on allergen sensitization patterns among pediatric populations in different regions of Turkey. For instance, at a pediatric allergy center in Eskişehir, Central Anatolia, Poaceae was identified as the most common sensitization in allergic rhinitis cases [32], while grass pollen sensitization was more dominant in Batman, Southeastern Anatolia [33]. In another study conducted in the Mediterranean region of our country, which included 866 patients diagnosed with AR, clinical characteristics were evaluated alongside local climate data and pollen diversity in the urban environment. The findings showed that grasses, cereal mixtures, and mites accounted for the majority of allergic rhinoconjunctivitis cases. Additional prominent allergens linked to the region's climate and flora included olives and cockroaches. Notably, Graminea species were the main allergens from April through June, Cupressus spp. between February and March, and Pinus spp. from March through June [34]. In our study group, which predominantly showed pollen sensitization, Olea europaea was the most common allergen ($n=124$, 44.3%), followed by a grass mix (Ryegrass, Timothy grass, Bermuda grass, Fescue grass) ($n=72$, 25.7%), *Parietaria officinalis* ($n=32$, 12%), *Phleum* ($n=28$, 10%), and *Betula alba* ($n=12$, 4.4%).

To further illustrate the research on aeroallergen sensitization within the pediatric population, a comparative study examined sensitization patterns between two major cities with differing altitudes, Istanbul and Erzurum [35]. This study found that grass pollen sensitization, particularly from species such as Orchard grass (*Dactylis glomerata*), Timothy grass (*Phleum pratense*), Vernal grass (*Poa annua*), Kentucky bluegrass (*Poa pratensis*), and Ryegrass (*Lolium spp*.), was the most prevalent in both regions, with high altitude identified as a contributing risk factor. Additionally, another retrospective analysis involving 1,307 patients revealed that the predominant aeroallergens in polysensitized children were Dermatophagoides pteronyssinus (66.7%), Dermatophagoides farinae (67.0%), a grass mixture (43.4%), grain pollen (43.6%), Alternaria alternata (37.8%), and animal dander (26.9%). Consistent with our findings, this study also reported significantly higher age and total IgE levels in polysensitized children compared to those with monosensitization, although no differences were observed regarding gender, absolute eosinophil count, or asthma association [36].

Additionally, our findings reinforce the notion that polysensitized patients experience a different clinical profile compared to monosensitized individuals, often with more severe symptoms and a higher likelihood of asthma development later in life [37, 38] in addition to having higher total and sIgE levels [18]. In a study involving 2,415 patients with AR [16], no significant differences were observed in symptom duration between monosensitized and polysensitized individuals. However, polysensitized patients experienced more severe symptoms, with *Parietaria* pollen being more frequently implicated in moderate to severe symptomatology. In our study, olive and grass pollens were identified as the most frequent contributors to moderate to severe symptoms; however, this difference did not reach statistical significance.

Interestingly, our analysis revealed that younger patients tended to be sensitive to mold and house dust mites, which are common household allergens. This supports literature suggesting that early exposure to these allergens may play a significant role in the development of allergic conditions [39–41]. Longitudinal studies evaluating exposure to household mold before the development of asthma symptoms have shown a risk for asthma in populations susceptible to *Penicillium*, *Aspergillus*, and *Cladosporium* species [40].

Symptoms in patients with AR change with age. Especially, ocular findings become more prominent with increasing allergen exposure and significantly affect the quality of life of patients in all age groups [42]. In our study, age-related changes in symptomatology were also observed, particularly with ocular findings becoming more pronounced with increased allergen exposure.

While our study offers significant insights, it is limited by its retrospective design and single-center data, which may restrict the generalizability of our conclusions. We advocate for larger, multi-center studies to further elucidate the complexities of allergic rhinitis in pediatric populations.

In conclusion, the complexity of childhood allergic rhinitis is highlighted by the clear associations among age, sensitization patterns, and symptom profiles. Patients with sensitivity to pollen, an outdoor allergen, predominantly experienced persistent and moderate-to-severe symptoms, whereas those sensitized to house dust mites, an indoor allergen, mainly exhibited mild symptoms, and patients with mold sensitivity tended to have moderate-to-severe symptoms. Within the context of Turkey's diverse regional characteristics and the influence of global climate change, these findings underscore the necessity of tailoring preventive and therapeutic strategies to local allergen profiles. Moreover, approaches suggesting that monosensitization may progress to polysensitization over time, alongside evidence supporting the role of allergen immunotherapy in preventing sensitization to novel allergens, emphasize the importance of early intervention in at-risk children. Further research on regional sensitization patterns will contribute to developing more targeted management strategies for childhood allergic rhinitis.

Clinical trial number
Not applicable.

Authors' contributions
Damla Baysal Bakır wrote the main manuscript text and prepared figures and tables. All authors reviewed the manuscript.

Data availability
All included studies are available in their respective journals, and all supporting data are clearly stated in the manuscript. A comprehensive list of scanned references is available upon request, from the corresponding author. Dr. Damla Baysal Bakır, e-mail:damla.baysalbakir@deu.edu.tr.

Declarations

Ethics approval and consent to participate
This study was conducted in accordance with the Declaration of Helsinki and was approved by Dokuz Eylul University Non-Interventional Research Ethics Committee (Approval No: 2023/41–14). Access permission was obtained from the archive and statistics unit of the chief physician's office of the practice and research hospital, and verbal consent was obtained from the patients' parents for the use of their medical data in accordance with the Personal Data Protection Law. The ethics committee did not require written informed consent for this retrospective study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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