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Original Article

Comparison of allergen types and complete blood count in pediatric allergic rhinitis

Li Liu[1,2*], Xiangqian Qiu[2*], Shengli Gao[2*], Qingxiang Zeng[2], Jing Ma[3], Wenlong Liu[2]

[1]Jinan University, Guangzhou, Guangdong, China; [2]Department of Otolaryngology, Guangzhou Women and Children's Medical Center, Guangzhou Medical University, Guangzhou, Guangdong, China; [3]Department of Otolaryngology, Head and Neck Surgery, Kunming Children's Hospital, Kunming, Yunnan, China. [*]Equal contributors.

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Abstract: Background: Allergic rhinitis (AR) is a highly prevalent immunoglobulin E (IgE)-mediated disease that significantly impacts quality of life. While hematological parameters (complete blood count [CBC]) are linked to inflammation in adult AR, their relevance to pediatric populations remains unclear. This study aimed to characterize allergen sensitization profiles, CBC parameters, and immunoglobulin features in pediatric AR patients across demographic subgroups (sex, age, disease duration). Methods: A retrospective study included 253 children with AR (aged 3-12 years; 176 males, 77 females) who tested positive for specific IgE (sIgE) to one or more inhalant allergens (≥ 0.35 IU/mL). Demographics, symptom scores (nasal/ocular), family history, sIgE, CBC, total immunoglobulin E (tIgE), immunoglobulin A (IgA), immunoglobulin G (IgG), immunoglobulin M (IgM), and complement component 4 (C4) were assessed. Statistical analyses were performed to compare groups based on sex, age (preschool vs. school-age), and disease duration, and to examine correlations between parameters and symptom scores. Results: House dust mites (HDM) (including *Dermatophagoides farinae* [D. *farinae*]: 98.81% and *Dermatophagoides pteronyssinus* [D. *pteronyssinus*]: 97.63%) were the predominant sensitizing allergens, predominantly with high-grade sensitization (classes 3-6). Males exhibited significantly higher tIgE, D. *farinae* sIgE, D. *pteronyssinus* sIgE, German cockroach sIgE, IgA, C4, neutrophils, monocytes, red blood cell (RBC) count, red cell distribution width-coefficient of variation (RDW-CV), and mean corpuscular volume (MCV) compared to females. School-age children and those with longer disease duration had higher HDM sensitization rates (classes 3-6), Total Nasal Symptom Score (TNSS), IgG, IgA, neutrophils, and specific platelet indices (mean platelet volume [MPV], platelet-large cell ratio [P-LCR]), but lower eosinophils compared to preschoolers or those with short disease duration. Eosinophils, basophils, neutrophils, platelets, tIgE, HDM-sIgE, IgA, hematocrit (HCT), and red cell distribution width-standard deviation (RDW-SD) correlated significantly with nasal symptom scores. After adjusting for multiple comparisons and confounding factors, IgA remained independently associated with longer disease duration and showed significant correlations with nasal symptom scores. Conclusion: HDM are the primary allergens in the pediatric AR population in Guangzhou. Significant sex-, age-, and duration-related differences exist in sensitization patterns and immune and CBC profiles. After rigorous statistical control for multiple comparisons, only total IgE, absolute basophil count, and eosinophil percentage correlated significantly with symptom severity, highlighting their potential as accessible biomarkers for assessing disease activity.

Keywords: Allergic rhinitis, pediatric, complete blood count (CBC), inhalant allergens, immunoglobulin E (IgE), Dermatophagoides

Introduction

AR ranks among the most prevalent atopic diseases worldwide, with a global prevalence ranging from 10% to 20% [1]. AR is primarily driven by IgE, resulting in chronic mucosal inflammation within the nasal passages. Common symptoms include nasal obstruction, rhinorrhea, sneezing, and pruritus, which markedly impair patients' quality of life and contribute to a significant socioeconomic burden [2].

Longitudinal surveillance in China revealed a 58.6% relative increase in self-diagnosed AR among adults over a six-year period [3]. Contemporary epidemiological studies attribute the persistent upward trajectory of AR incidence to the combined effects of environmen-

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Table 1. Determination of allergen results

Severity level	sIgE concentration (IU/mL)	Outcome
0	< 0.35	Negative
1	0.35-0.7	Low
2	0.7-3.5	Medium
3	3.5-17.5	Increased
4	17.5-50	High
5	50-100	Very high
6	> 100	Extremely high

Abbreviations: IgE, immunoglobulin E; sIgE, specific immunoglobulin E.

tal determinants, climate factors, and evolving lifestyle factors [4, 5].

Hematological analyses demonstrate a strong association between peripheral eosinophil counts and T helper 2 (Th2)-mediated inflammation in AR. Comparative studies reveal elevated eosinophil parameters (absolute counts and relative ratios to neutrophils/lymphocytes) in AR patients compared with healthy controls, underscoring eosinophils' pivotal role in AR pathogenesis [6, 7]. Elevated platelet-activating factor (PAF) concentrations have been consistently detected in AR patients, where this lipid mediator actively contributes to the development of nasal obstruction and rhinorrhea [8]. Moreover, emerging evidence indicates that systemic inflammatory markers, particularly the neutrophil-to-lymphocyte ratio (NLR) and platelet-to-lymphocyte ratio (PLR), correlate significantly with disease severity in adult AR cases [6]. Notably, AR patients, particularly those with comorbid sinusitis, exhibit significantly elevated erythrocyte counts compared with healthy controls, potentially reflecting compensatory mechanisms secondary to chronic hypoxic conditions [9].

Despite these findings, the clinical relevance of CBC parameters in pediatric AR remains poorly characterized. To address this knowledge gap, we performed a detailed analysis of clinical records from a cohort of 253 pediatric AR patients, systematically evaluating: (1) Allergen sensitization patterns; (2) CBC profiles; and (3) Immunoglobulin characteristics across various demographic (age, sex) and clinical (disease duration) subgroups. Specifically, we aimed to determine whether previously reported associations between hematological parameters and AR severity in adults hold true in children, and to what extent these associations are independent of age-related immune maturation. These findings may provide valuable insights to inform early diagnostic approaches and personalized therapeutic strategies for childhood AR.

Material and methods

Subjects

We conducted a retrospective observational study involving 253 pediatric patients (age range: 3-12 years) with clinically confirmed AR. Participants were recruited consecutively from our center over an 11-month period (November 2023-September 2024).

The diagnosis of AR was confirmed as described in the Allergic Rhinitis and its Impact on Asthma (ARIA) guidelines. Inclusion criteria required participants to meet at least two of the following clinical manifestations: recurrent sneezing episodes, rhinorrhea, nasal pruritus, or nasal obstruction. Quantitative detection of allergen-specific IgE antibodies (≥ 0.35 IU/mL) was required for at least one of the following aeroallergens: *Dermatophagoides farinae*, *Dermatophagoides pteronyssinus*, cat dander, dog dander, German cockroach, fungi, or weed pollen, as measured by the ImmunoCAP system. Sensitization severities were categorized into six grades based on allergen-specific IgE concentrations (**Table 1**).

The following subjects were excluded: (1) Children with severe asthma or other chronic respiratory diseases; (2) Children with congenital immunodeficiency, autoimmune diseases, or those undergoing immunosuppressive therapy; and (3) Children with other severe systemic diseases. The Ethics Committee of Guangzhou Women and Children's Medical Center reviewed and approved this protocol (No. 261A01). Prior to enrollment, written consent was secured from each child's legal guardian.

Data collection

Demographic and clinical information, including age, sex, duration of illness, personal allergy background, and familial predisposition, were systematically obtained via standardized questionnaires and electronic health records.

Table 2. Characteristics of study subjects

Cases	253
Age (years)	8.0 (6.0-10.0)
Gender, n (%)	
Male	176 (69.6)
Female	77 (30.4)
Disease duration (years)	2.0 (1.0-4.0)
TNSS	7 (5-9)
Nasal itch	2 (1-2)
Sneezing	1 (1-2)
Rhinorrhea	2 (1-3)
Nasal congestion	2 (2-3)
Eye symptoms	1 (0-2)
tIgE (kU/L)	271.0 (102.5-598.0)
Family history, n (%)	
Yes	166 (65.6)
No	87 (34.4)
Age group, n (%)	
Preschool-aged	85 (33.6)
School-aged	168 (66.4)
Disease duration, n (%)	
≤ 2 years	139 (54.9)
> 2 years	114 (45.1)
Allergen sensitization, n (%)	
D. farinae	250 (98.8)
D. pteronyssinus	247 (97.6)
German cockroach	51 (20.2)
Cat dander	32 (12.7)
Fungi	16 (6.3)
Dog dander	15 (5.9)

TNSS, total nasal symptom score; IgE, immunoglobulin E; tIgE, total immunoglobulin E; *D. farinae*, *Dermatophagoides farinae*; *D. pteronyssinus*, *Dermatophagoides pteronyssinus*.

Nasal symptoms (congestion, rhinorrhea, sneezing, and itching) and ocular symptoms (itching, redness) were evaluated using a 4-point severity scale: 0 (asymptomatic), 1 (mild), 2 (moderate), and 3 (severe).

Laboratory tests

Blood samples were collected for allergen-sIgE testing, as well as for the measurement of IgA, IgG, IgM, and total IgE, and for a CBC.

Statistical analyses

Statistical analyses utilized SPSS 19.0. Measurement data underwent normality (Shapiro-Wilk) and homogeneity of variance (Levene's test) assessments. Normally distributed variables are expressed as mean ± SD ($\bar{x} \pm s$), non-normal data as median [IQR] (M [Q1-Q3]), and categorical variables as counts (percentages). For group comparisons, all continuous variables were first tested for normality. Independent *t*-tests analyzed parametric data; Mann-Whitney U tests addressed non-parametric or heteroscedastic data. Categorical comparisons employed χ^2 or Fisher's exact tests. Variable relationships were evaluated via Spearman correlation. For correlation analysis, associations between all laboratory parameters (including CBC indices, immunoglobulins, complement, and allergen-specific IgE) and symptom scores (TNSS and individual nasal/ocular scores) were evaluated, with the complete results presented in Table S1. To control for multiple comparisons, we applied false discovery rate (FDR) correction using the Benjamini-Hochberg procedure, with adjusted *P* values reported as *q*-values. Multivariable linear and logistic regression analyses, adjusting for age and sex, were performed for variables showing significant associations with disease duration in univariate analyses ($P < 0.05$) - including IgA, absolute eosinophil count (AEC), eosinophil percentage (EOS%), platelet-large cell ratio (P-LCR), complement C4, neutrophil percentage (NEUT%), and cat dander sensitization - to evaluate their independent association with disease duration. Results are presented as regression coefficients (B) or odds ratios (OR) with 95% confidence intervals (CI), and detailed results are shown in Table S2. All tests were two-sided with significance at $P < 0.05$ and $q < 0.05$ after correction.

Results

Demographic and clinical information

Our study enrolled 253 AR patients aged 3-12 years (176 males [69.6%], 77 females [30.4%]). A positive family history of allergic diseases was documented in 166 cases (65.6%), highlighting a substantial genetic predisposition within the study population (**Table 2**).

Among these cases, the sensitization profiles to seven inhalant allergens were as follows: D. *farinae* (98.81%); D. *pteronyssinus* (97.63%); German cockroach (20.16%); cat dander (12.65%); fungi (6.32%); dog dander

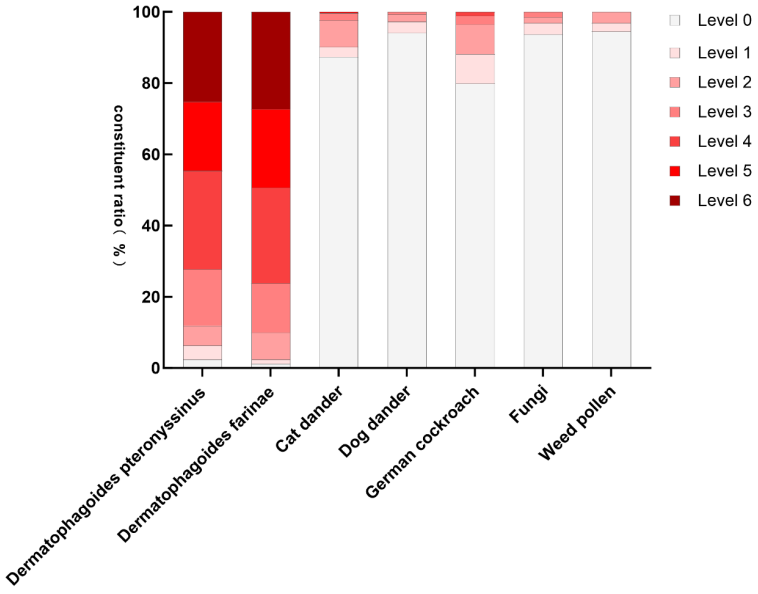

Figure 1. Distribution of sensitization levels to seven types of inhaled allergens.

(5.93%); and weed pollen (5.53%). A quantitative analysis of sensitization intensity indicated that arthropod allergens, especially D. *farinae* and D. *pteronyssinus*, predominantly exhibited high-grade sensitization (grades 3-6) according to standardized allergen classification scales, as shown in **Figure 1**.

Comparison of allergen types and CBC of pediatric AR according to sex

The male and female groups showed no statistically significant differences in age, disease duration, nasal symptoms, or ocular symptom scores ($P > 0.05$). The allergen sensitization profiles of the 176 male and 77 female children with AR are shown in **Table 3**. Specific IgE levels for D. *farinae* and D. *pteronyssinus* revealed that the majority of positive results in both genders were concentrated in classes 3-6 (moderate-to-high levels) ($P < 0.05$). Notably, statistically significant differences in the distribution of specific IgE levels between males and females were observed for both D. *farinae* ($\chi^2 = 6.154$, $P < 0.05$) and D. *pteronyssinus* ($\chi^2 = 11.45$, $P < 0.05$). After false discovery rate (FDR) correction for multiple comparisons, the difference for D. *farinae* remained significant ($q = 0.011$), whereas the difference for D. *pteronyssinus* did not survive correction ($q = 0.064$). The prevalence of positive specific IgE to German cockroach was also significantly higher in males than in females ($\chi^2 = 6.563$, $P < 0.05$), but this difference was no longer significant after FDR correction ($q = 0.064$).

Males demonstrated significantly elevated serum levels of total IgE, IgA, and complement C4 compared to females (all $P < 0.05$). After FDR correction, only IgA remained significant ($q = 0.016$), while total IgE and C4 did not ($q = 0.102$ and 0.124, respectively). Males also had significantly higher red blood cell (RBC) count, red cell distribution width-coefficient of variation (RDW-CV), absolute neutrophil count (ANC), absolute monocyte count (AMC), neutrophil percentage (NEUT%), and mean corpuscular volume (MCV) (all $P < 0.05$). Following FDR correction, RBC ($q = 0.011$), MCV ($q = 0.011$), ANC ($q = 0.0498$), and NEUT% ($q = 0.016$) remained significant, whereas RDWCV ($q = 0.064$) and AMC ($q = 0.135$) did not. Conversely, females showed significantly higher mean corpuscular hemoglobin (MCH) and lymphocyte percentage (LYMPH%) than males (both $P < 0.05$). After FDR correction, LYMPH% remained significant ($q = 0.011$), but MCH did not ($q = 0.102$).

Comparison of allergen types and CBC of pediatric AR according to age

School-age children exhibited significantly longer disease duration ($P < 0.001$) and higher TNSS ($P = 0.004$) than preschool counterparts. After FDR correction, TNSS remained significant ($q = 0.024$). This difference was especially pronounced for the symptoms of sneezing, rhinorrhea, and nasal congestion (all $P < 0.05$). Among individual symptoms, sneezing ($P = 0.007$) retained significance after correction ($q = 0.030$), whereas rhinorrhea ($P = 0.021$, $q = 0.065$) and nasal congestion ($P = 0.038$, $q = 0.107$) did not.

The distribution of inhalant allergens among children of different ages is detailed in **Table 4**. School-age children showed significantly higher sensitization rates to *D. farinae* and *D.*

Table 3. Comparison of allergen types and immunological test as well as CBC of pediatric AR according to sex

Variable	Male (n = 176)	Female (n = 77)	χ^2	*p*-value	*q*-value*
Age (years)	8.0 (6.0-10.0)	7.0 (5.0-9.0)		0.164	0.365
Disease duration (years)	2.0 (1.0-4.0)	2.0 (1.0-3.0)		0.143	0.339
TNSS	7.0 (5.0-9.0)	7.0 (5.0-9.0)		0.362	0.579
Nasal itch	2.0 (1.0-2.0)	2.0 (1.0-2.0)		0.433	0.634
Sneezing	1.0 (1.0-2.0)	1.0 (1.0-2.0)		0.880	0.920
Rhinorrhea	1.0 (1.0-3.0)	2.0 (1.0-3.0)		0.891	0.920
Nasal congestion	2.0 (2.0-3.0)	2.0 (1.5-3.0)		0.230	0.424
Eye symptoms	1.0 (0.0-2.0)	1.0 (0.0-2.0)		0.312	0.512
Family history, n (%)					
Yes	118 (67.0)	48 (62.3)		0.468	0.666
No	58 (33.0)	29 (37.7)			
D. *pteronyssinus*, n (%)	173 (98.3)	74 (96.1)	0.366	0.545	0.696
Level 0	3 (1.7)	3 (3.9)	0.366	0.545	0.696
Level 1	4 (2.3)	6 (7.8)	2.968	0.085	0.247
Level 2	8 (4.5)	6 (7.8)	1.080	0.299	0.504
Level 3	26 (14.8)	14 (18.2)	0.468	0.494	0.687
Level 4	53 (30.1)	17 (22.1)	1.728	0.189	0.390
Level 5	35 (19.9)	14 (18.2)	0.100	0.752	0.860
Level 6	47 (26.7)	17 (22.1)	0.607	0.436	0.634
Level 0-2	15 (8.5)	15 (19.5)	6.154	0.013	0.064
Level 3-6	161 (91.5)	62 (80.5)	6.154	0.013	0.064
D. *farinae*, n (%)	176 (100.0)	74 (96.1)		0.027	0.102
Level 0	0 (0.0)	3 (3.9)		0.027	0.102
Level 1	3 (1.7)	0 (0.0)		0.555	0.696
Level 2	7 (4.0)	12 (15.6)	10.390	0.001	**0.011**
Level 3	26 (14.8)	9 (11.7)	0.428	0.513	0.696
Level 4	49 (27.8)	19 (24.7)	0.273	0.601	0.740
Level 5	38 (21.6)	18 (23.4)	0.099	0.753	0.860
Level 6	53 (30.1)	16 (20.8)	2.353	0.125	0.308
Level 0-2	10 (5.7)	15 (19.5)	11.450	0.001	**0.011**
Level 3-6	166 (94.3)	62 (80.5)	11.450	0.001	**0.011**
Cat dander, n (%)	26 (14.8)	6 (7.8)	2.362	0.124	0.308
Dog dander, n (%)	13 (7.4)	2 (2.6)	1.428	0.232	0.424
German cockroach, n (%)	43 (24.4)	8 (10.4)	6.563	0.010	0.064
Fungi, n (%)	9 (5.1)	7 (9.1)	1.430	0.232	0.424
Weed pollen, n (%)	12 (6.8)	2 (2.6)	1.107	0.293	0.504
tIgE (kU/L)	302.0 (114.3-622.8)	179.0 (73.1-469.5)		0.026	0.102
IgG (g/L)	11.3 (9.8-12.8)	11.5 (9.9-13.0)		0.546	0.696
IgA (g/L)	1.72 (1.35-2.20)	1.54 (1.04-1.86)		0.002	**0.016**
IgM (g/L)	1.25 (0.94-1.54)	1.30 (1.06-1.67)		0.089	0.248
C3 (g/L)	0.96 (0.85-1.06)	0.91 (0.84-1.00)		0.065	0.198
C4 (g/L)	0.19 (0.16-0.24)	0.19 (0.15-0.22)		0.035	0.124
WBC ($\times 10^9$/L)	7.84 (6.80-9.30)	7.60 (6.32-9.05)		0.171	0.365
RBC ($\times 10^{12}$/L)	4.72 (4.49-4.96)	4.51 (4.36-4.77)		0.001	**0.011**
Hb (g/L)	126.9 ± 9.0	124.5 ± 9.3		0.058	0.186
Hct (%)	38.3 (36.8-40.0)	37.6 (36.2-39.7)		0.170	0.365

MCV (fL)	81.7 (79.3-83.9)	83.7 (81.5-86.0)	< 0.001	**0.011**
MCH (pg)	27.2 (26.3-28.0)	27.6 (26.8-28.4)	0.025	0.102
MCHC (g/L)	330.4 ± 11.9	328.4 ± 11.6	0.218	0.424
RDW-SD (fL)	38.0 (35.9-39.5)	37.9 (36.7-39.3)	0.780	0.860
RDW-CV (%)	12.8 (12.3-13.3)	12.5 (12.1-13.2)	0.011	0.064
PLT (×10^9/L)	320.0 (286.0-360.8)	321.0 (289.5-368.0)	0.774	0.860
MPV (fL)	9.3 (8.9-9.9)	9.4 (8.8-10.1)	0.980	0.980
PDW (fL)	9.80 (9.00-11.28)	10.21 (8.80-11.10)	0.793	0.860
P-LCR (%)	18.7 (15.7-23.6)	19.3 (14.6-24.8)	0.775	0.860
PCT (%)	0.30 (0.27-0.34)	0.30 (0.27-0.34)	0.943	0.958
ANC (×10^9/L)	3.45 (2.74-4.51)	3.16 (2.23-3.94)	0.007	**0.0498**
ALC (×10^9/L)	3.15 (2.44-3.86)	3.30 (2.74-4.03)	0.121	0.308
AMC (×10^9/L)	0.51 (0.38-0.64)	0.48 (0.34-0.57)	0.040	0.135
AEC (×10^9/L)	0.44 (0.30-0.69)	0.39 (0.26-0.66)	0.280	0.498
ABC (×10^9/L)	0.04 (0.02-0.06)	0.04 (0.02-0.06)	0.414	0.631
NEUT%	46.0 (38.0-52.8)	41.0 (35.0-46.0)	0.002	**0.016**
LYMPH%	40.5 ± 9.4	45.1 ± 9.5	< 0.001	**0.011**
MONO%	6.0 (5.0-7.0)	6.0 (5.0-7.0)	0.403	0.629
EOS%	5.0 (4.0-9.0)	6.0 (3.5-8.5)	0.763	0.860
BASO%	0.0 (0.0-1.0)	0.0 (0.0-1.0)	0.862	0.919

Data are presented as median (interquartile range), mean ± SD, or n (%). *p*-values were calculated using the Mann-Whitney U test for continuous variables and the Chi-square test (or Fisher's exact test when appropriate) for categorical variables. **q*-value: false discovery rate (FDR)-adjusted *P* value using the Benjamini-Hochberg procedure. Bold indicates statistical significance after FDR correction (q < 0.05). For ANC, the exact q-value was 0.0498. Abbreviations: TNSS, total nasal symptom score; IgE, immunoglobulin E; tIgE, total immunoglobulin E; D. *farinae*, Dermatophagoides farinae; D. *pteronyssinus*, Dermatophagoides *pteronyssinus*; WBC, white blood cell; RBC, red blood cell; Hb, hemoglobin; Hct, hematocrit; MCV, mean corpuscular volume; MCH, mean corpuscular hemoglobin; MCHC, mean corpuscular hemoglobin concentration; RDW-SD, red cell distribution width (standard deviation); RDW-CV, red cell distribution width (coefficient of variation); PLT, platelet; MPV, mean platelet volume; PDW, platelet distribution width; P-LCR, platelet-large cell ratio; PCT, plateletcrit; ANC, absolute neutrophil count; ALC, absolute lymphocyte count; AMC, absolute monocyte count; AEC, absolute eosinophil count; ABC, absolute basophil count; NEUT%, neutrophil percentage; LYMPH%, lymphocyte percentage; MONO%, monocyte percentage; EOS%, eosinophil percentage; BASO%, basophil percentage.

Table 4. Comparison of allergen types and immunological test as well as CBC of pediatric AR according to age

Variable	Preschool age (n = 85)	School age (n = 168)	χ^2	*p*-value	*q*-value*
Age (years)	5.0 (4.0-6.0)	9.0 (8.0-11.0)		< 0.001	**0.005**
Gender, n (%)				0.232	0.377
Male	55 (64.7)	121 (72.0)			
Female	30 (35.3)	47 (28.0)			
Disease duration (years)	2.0 (1.0-2.0)	3.0 (2.0-5.0)		< 0.001	**0.005**
TNSS	6.0 (5.0-8.0)	7.0 (5.3-9.0)		0.004	**0.024**
Nasal itch	2.0 (1.0-2.0)	2.0 (1.0-2.0)		0.724	0.777
Sneezing	1.0 (1.0-2.0)	1.0 (1.0-3.0)		0.007	**0.030**
Rhinorrhea	1.0 (1.0-2.0)	2.0 (1.0-3.0)		0.021	0.065
Nasal congestion	2.0 (1.0-3.0)	2.0 (2.0-3.0)		0.038	0.107
Eye symptoms	1.0 (0.0-2.0)	1.0 (0.0-2.0)		0.228	0.377
Family history, n (%)				0.291	0.450
Yes	52 (61.2)	114 (67.9)			
No	33 (38.8)	54 (32.1)			

D. *pteronyssinus*, n (%)	82 (96.5)	165 (98.2)	0.179	0.672	0.740
Level 0	3 (3.5)	3 (1.8)	0.179	0.672	0.740
Level 1	4 (4.7)	6 (3.6)	0.009	0.924	0.924
Level 2	8 (9.4)	6 (3.6)	3.683	0.055	0.132
Level 3	14 (16.5)	26 (15.5)	0.042	0.838	0.851
Level 4	28 (32.9)	42 (25.0)	1.779	0.182	0.320
Level 5	11 (12.9)	38 (22.6)	3.385	0.066	0.143
Level 6	17 (20.0)	47 (28.0)	1.900	0.168	0.307
Level 0-2	15 (17.6)	15 (8.9)	4.105	0.043	0.112
Level 3-6	70 (82.4)	153 (91.1)	4.105	0.043	0.112
D. *farinae*, n (%)	84 (98.8)	166 (98.8)	0.366	0.545	0.695
Level 0	1 (1.2)	2 (1.2)	0.366	0.545	0.695
Level 1	1 (1.2)	2 (1.2)	0.366	0.545	0.695
Level 2	12 (14.1)	7 (4.2)	8.047	0.005	**0.027**
Level 3	16 (18.8)	19 (11.3)	2.673	0.102	0.207
Level 4	24 (28.2)	44 (26.2)	0.120	0.729	0.777
Level 5	14 (16.5)	42 (25.0)	2.382	0.123	0.242
Level 6	17 (20.0)	52 (31.0)	3.413	0.065	0.143
Level 0-2	14 (16.5)	11 (6.5)	6.241	0.013	**0.047**
Level 3-6	71 (83.5)	157 (93.5)	6.241	0.013	**0.047**
Cat dander, n (%)	9 (10.6)	23 (13.7)	0.492	0.483	0.655
Dog dander, n (%)	6 (7.1)	9 (5.4)	0.293	0.588	0.721
German cockroach, n (%)	13 (15.3)	38 (22.6)	1.882	0.170	0.307
Fungi, n (%)	4 (4.7)	12 (7.1)	0.229	0.632	0.723
Weed pollen, n (%)	3 (3.5)	11 (6.5)	0.491	0.484	0.655
tIgE (kU/L)	185.0 (91.6-465.0)	297.0 (107.3-631.8)		0.051	0.128
IgG (g/L)	10.3 (8.7-11.4)	11.7 (10.4-13.5)		< 0.001	**0.005**
IgA (g/L)	1.36 (0.98-1.81)	1.77 (1.45-2.27)		< 0.001	**0.005**
IgM (g/L)	1.30 (0.99-1.65)	1.25 (0.95-1.53)		0.360	0.532
C3 (g/L)	0.97 (0.86-1.06)	0.94 (0.84-1.03)		0.377	0.545
C4 (g/L)	0.20 (0.16-0.24)	0.19 (0.16-0.22)		0.245	0.388
WBC ($\times 10^9$/L)	8.31 (7.10-9.63)	7.54 (6.62-8.95)		0.018	0.059
RBC ($\times 10^{12}$/L)	4.64 (4.41-4.89)	4.70 (4.43-4.96)		0.222	0.377
Hb (g/L)	125.6 ± 8.8	126.9 ± 9.3		0.065	0.143
Hct (%)	37.4 (36.3-39.1)	38.4 (36.8-40.5)		0.007	**0.030**
MCV (fL)	81.5 (78.3-84.1)	82.9 (80.3-84.8)		0.009	**0.037**
MCH (pg)	27.1 (26.1-27.8)	27.4 (26.6-28.3)		0.016	0.055
MCHC (g/L)	330.7 ± 11.9	329.4 ± 11.8		0.623	0.723
RDW-SD (fL)	37.5 (35.8-38.6)	38.4 (36.3-39.8)		0.003	**0.020**
RDW-CV (%)	12.7 (12.3-13.3)	12.7 (12.2-13.3)		0.575	0.719
PLT ($\times 10^9$/L)	339.0 (297.5-377.5)	311.0 (279.0-356.8)		0.006	**0.030**
MPV (fL)	9.0 (8.6-9.6)	9.4 (9.0-10.1)		< 0.001	**0.005**
PDW (fL)	9.4 (8.7-11.0)	10.2 (9.1-11.3)		0.029	0.086
P-LCR (%)	16.2 (13.5-21.2)	20.1 (16.4-25.7)		< 0.001	**0.005**
PCT (%)	0.31 (0.27-0.34)	0.30 (0.26-0.35)		0.454	0.642
ANC ($\times 10^9$/L)	3.36 (2.55-4.44)	3.36 (2.65-4.31)		0.836	0.851
ALC ($\times 10^9$/L)	3.80 (2.97-4.28)	2.97 (2.46-3.61)		< 0.001	**0.005**
AMC ($\times 10^9$/L)	0.52 (0.40-0.67)	0.48 (0.36-0.60)		0.144	0.275
AEC ($\times 10^9$/L)	0.46 (0.30-0.66)	0.41 (0.27-0.68)		0.317	0.479

ABC (×10^9/L)	0.04 (0.02-0.06)	0.04 (0.02-0.06)	0.634	0.723
NEUT%	42.0 (35.0-48.5)	46.0 ± 10.1	0.003	**0.020**
LYMPH%	44.4 ± 10.3	40.6 ± 9.1	0.002	**0.016**
MONO%	6.0 (5.0-7.0)	6.0 (5.0-7.0)	0.626	0.723
EOS%	5.0 (4.0-8.0)	6.0 (4.0-9.0)	0.744	0.780
BASO%	0.0 (0.0-1.0)	1.0 (0.0-1.0)	0.078	0.164

Data are presented as median (interquartile range), mean ± SD, or n (%). *p*-values were calculated using the Mann-Whitney U test for continuous variables and the Chi-square test (or Fisher's exact test when appropriate) for categorical variables. **q*-value: false discovery rate (FDR)-adjusted *P* value using the Benjamini-Hochberg procedure. Bold indicates statistical significance after FDR correction (q < 0.05). For ANC, the exact q-value was 0.0498. Abbreviations: TNSS, total nasal symptom score; IgE, immunoglobulin E; tIgE, total immunoglobulin E; D. *farinae*, Dermatophagoides farinae; D. *pteronyssinus*, Dermatophagoides *pteronyssinus*; WBC, white blood cell; RBC, red blood cell; Hb, hemoglobin; Hct, hematocrit; MCV, mean corpuscular volume; MCH, mean corpuscular hemoglobin; MCHC, mean corpuscular hemoglobin concentration; RDW-SD, red cell distribution width (standard deviation); RDW-CV, red cell distribution width (coefficient of variation); PLT, platelet; MPV, mean platelet volume; PDW, platelet distribution width; P-LCR, platelet-large cell ratio; PCT, plateletcrit; ANC, absolute neutrophil count; ALC, absolute lymphocyte count; AMC, absolute monocyte count; AEC, absolute eosinophil count; ABC, absolute basophil count; NEUT%, neutrophil percentage; LYMPH%, lymphocyte percentage; MONO%, monocyte percentage; EOS%, eosinophil percentage; BASO%, basophil percentage.

pteronyssinus (levels 3-6) than preschoolers (χ^2 = 6.241, *P* = 0.013; χ^2 = 4.105, *P* = 0.043, respectively). After FDR correction, the difference for D. *farinae* remained significant (q = 0.047), while the difference for D. *pteronyssinus* did not (q = 0.112).

The total serum IgG and IgA levels were significantly higher in the school-age group (both *P* < 0.001), and both remained significant after FDR correction (q = 0.005 for each). Compared to the school-age group, the preschool group showed significantly elevated white blood cell (WBC) count, platelet (PLT) count, LYMPH%, and absolute lymphocyte count (ALC) (all *P* < 0.05). Following FDR correction, PLT (q = 0.030), LYMPH% (q = 0.016), and ALC (q = 0.005) remained significant, while WBC did not (q = 0.059). Conversely, the school-age group exhibited significantly increased HCT, MCH, RDW-SD, platelet distribution width (PDW), MPV, P-LCR, neutrophil percentage (NEUT%), and MCV (all *P* < 0.05). After FDR correction, HCT (q = 0.030), RDW-SD (q = 0.020), MPV (q = 0.005), P-LCR (q = 0.005), NEUT% (q = 0.020), and MCV (q = 0.037) retained significance, whereas MCH (q = 0.055) and PDW (q = 0.086) did not.

Comparison of allergen types and CBC of pediatric AR according to disease duration

The long-duration group had a significantly older age distribution than the short-duration group (*P* < 0.001), with patients in this group being predominantly of school age.

While overall TNSS and individual symptoms (sneezing, rhinorrhea, congestion) showed no intergroup differences, nasal itching scores were significantly elevated in the short-duration group compared with long-duration group (*P* = 0.043). Additionally, a significantly higher proportion of patients with a family history of allergic diseases was observed in the long-duration group than in the short-duration group (*P* = 0.029). However, neither difference remained significant after FDR correction (q = 0.218 and 0.204, respectively).

The distribution of inhalant allergens among children with different disease durations is detailed in **Table 5**. Cat dander sensitization was significantly elevated in the long-duration group (χ^2 = 4.501, *P* = 0.034), but this difference did not survive FDR correction (q = 0.204).

The total serum IgG and IgA levels were significantly elevated in the long-duration group, while the complement C4 level was lower in the long-duration group all *P* < 0.05). Additionally, the P-LCR and NEUT% in the long-duration group were significantly higher than those in the short-duration group (*P* < 0.05), while elevated absolute eosinophil counts (AEC) and eosinophil percentages (EOS%) were observed in short-duration patients compared with long-duration counterparts (*P* < 0.05). After FDR correction, only IgA retained significance (q = 0.008); all other parameters (IgG, C4, P-LCR, NEUT%, AEC, EOS%) had q-values > 0.05 (0.106, 0.141, 0.157, 0.141, 0.218, and 0.204, respectively).

Table 5. Comparison of allergen types and immunological test as well as CBC of pediatric AR according to disease duration

Variable	≤ 2 years (n = 139)	> 2 years (n = 114)	χ^2	*p*-value	*q*-value*
Age (years)	7.0 (5.0-8.0)	9.0 (7.0-11.0)		< 0.001	**0.008**
Age group, n (%)				< 0.001	**0.008**
Preschool age	69 (49.6)	16 (14.0)			
School age	70 (50.4)	98 (86.0)			
Gender, n (%)				0.118	0.285
Male	91 (65.5)	85 (74.6)			
Female	48 (34.5)	29 (25.4)			
Disease duration (years)	1.0 (1.0-2.0)	4.5 (3.0-5.0)		< 0.001	**0.008**
TNSS	7.0 (5.0-8.0)	7.0 (5.0-9.0)		0.147	0.313
Nasal itch	2.0 (1.0-2.0)	2.0 (1.0-2.0)		0.043	0.218
Sneezing	1.0 (1.0-2.0)	1.0 (1.0-3.0)		0.105	0.267
Rhinorrhea	1.0 (1.0-3.0)	2.0 (1.0-3.0)		0.060	0.242
Nasal congestion	2.0 (1.0-3.0)	2.0 (2.0-3.0)		0.055	0.242
Eye symptoms	1.0 (0.0-2.0)	1.0 (0.0-2.0)		0.614	0.779
Family history, n (%)				0.029	0.204
Yes	83 (59.7)	83 (72.8)			
No	56 (40.3)	31 (27.2)			
D. *pteronyssinus*, n (%)	135 (97.1)	112 (98.2)	0.029	0.866	0.938
Level 0	4 (2.9)	2 (1.8)	0.029	0.866	0.938
Level 1	6 (4.3)	4 (3.5)	0.000	0.997	0.997
Level 2	11 (7.9)	3 (2.6)	2.409	0.121	0.285
Level 3	21 (15.1)	19 (16.7)	0.114	0.735	0.915
Level 4	38 (27.3)	32 (28.1)	0.017	0.897	0.940
Level 5	24 (17.3)	25 (21.9)	0.872	0.350	0.550
Level 6	35 (25.2)	29 (25.4)	0.002	0.962	0.992
Level 0-2	21 (15.1)	9 (7.9)	3.118	0.077	0.242
Level 3-6	118 (84.9)	105 (92.1)	3.118	0.077	0.242
D. *farinae*, n (%)	137 (98.6)	113 (99.1)	0.030	0.863	0.938
Level 0	2 (1.4)	1 (0.9)	0.030	0.863	0.938
Level 1	2 (1.4)	1 (0.9)	0.030	0.863	0.938
Level 2	14 (10.1)	5 (4.4)	2.915	0.088	0.255
Level 3	21 (15.1)	14 (12.3)	0.420	0.517	0.696
Level 4	35 (25.2)	33 (28.9)	0.452	0.501	0.696
Level 5	28 (20.1)	28 (24.6)	0.709	0.400	0.597
Level 6	37 (26.6)	32 (28.1)	0.067	0.797	0.938
Level 0-2	18 (12.9)	7 (6.1)	3.261	0.071	0.242
Level 3-6	121 (87.1)	107 (93.9)	3.261	0.071	0.242
Cat dander, n (%)	12 (8.6)	20 (17.5)	4.501	0.034	0.204
Dog dander, n (%)	7 (5.0)	8 (7.0)	0.441	0.507	0.696
German cockroach, n (%)	30 (21.6)	21 (18.4)	0.389	0.533	0.704
Fungi, n (%)	6 (4.3)	10 (8.8)	2.099	0.147	0.313
Weed pollen, n (%)	6 (4.3)	8 (7.0)	0.874	0.350	0.550
tIgE (kU/L)	255.0 (96.9-598.0)	271.0 (107.8-599.0)		0.881	0.938
IgG (g/L)	11.0 (9.5-12.6)	11.7 (10.3-13.5)		0.008	0.106
IgA (g/L)	1.56 (1.08-1.91)	1.82 (1.48-2.28)		< 0.001	**0.008**
IgM (g/L)	1.24 (0.95-1.60)	1.30 (0.99-1.55)		0.407	0.597

C3 (g/L)	0.95 (0.85-1.07)	0.94 (0.85-1.02)	0.278	0.470
C4 (g/L)	0.20 (0.16-0.24)	0.18 (0.15-0.22)	0.015	0.141
WBC ($\times 10^9$/L)	7.95 (6.69-9.26)	7.63 (6.71-9.30)	0.978	0.993
RBC ($\times 10^{12}$/L)	4.63 (4.41-4.88)	4.74 (4.44-4.99)	0.167	0.334
Hb (g/L)	125.8 ± 8.4	126.5 ± 10.0	0.317	0.523
Hct (%)	38.1 (36.6-39.5)	38.3 (36.6-40.3)	0.187	0.353
MCV (fL)	82.4 (80.0-84.4)	82.4 (79.5-84.7)	0.870	0.938
MCH (pg)	27.3 (26.5-28.0)	27.5 (26.3-28.3)	0.104	0.267
MCHC (g/L)	330.2 ± 11.6	329.3 ± 12.1	0.582	0.753
RDW-SD (fL)	37.7 (36.1-39.1)	38.2 (36.2-39.7)	0.089	0.255
RDW-CV (%)	12.6 (12.2-13.2)	12.8 (12.3-13.5)	0.147	0.313
PLT ($\times 10^9$/L)	330.0 (291.0-368.0)	310.0 (282.8-357.0)	0.179	0.347
MPV (fL)	9.2 (8.8-9.8)	9.4 (9.0-10.1)	0.093	0.256
PDW (fL)	9.7 (8.8-11.2)	10.2 (9.1-11.2)	0.394	0.597
P-LCR (%)	17.8 (14.9-23.0)	19.9 (16.2-25.3)	0.019	0.157
PCT (%)	0.30 (0.27-0.34)	0.30 (0.26-0.34)	0.513	0.696
ANC ($\times 10^9$/L)	3.26 (2.57-4.17)	3.46 (2.69-4.55)	0.212	0.378
ALC ($\times 10^9$/L)	3.30 (2.65-4.04)	3.01 (2.49-3.80)	0.072	0.242
AMC ($\times 10^9$/L)	0.51 (0.40-0.63)	0.48 (0.35-0.59)	0.161	0.332
AEC ($\times 10^9$/L)	0.49 (0.30-0.69)	0.40 (0.26-0.64)	0.042	0.218
ABC ($\times 10^9$/L)	0.04 (0.02-0.07)	0.04 (0.02-0.06)	0.200	0.367
NEUT%	43.3 ± 9.4	46.5 ± 11.3	0.015	0.141
LYMPH%	42.8 ± 9.2	40.8 ± 10.2	0.224	0.389
MONO%	7.0 (5.0-7.0)	6.0 (5.0-7.0)	0.059	0.242
EOS%	6.0 (4.0-9.0)	5.0 (3.0-8.3)	0.034	0.204
BASO%	0.0 (0.0-1.0)	0.0 (0.0-1.0)	0.853	0.938

Data are presented as median (interquartile range), mean ± SD, or n (%). *p*-values were calculated using the Mann-Whitney U test for continuous variables and the Chi-square test (or Fisher's exact test when appropriate) for categorical variables. **q*-value: false discovery rate (FDR)-adjusted *P* value using the Benjamini-Hochberg procedure. Bold indicates statistical significance after FDR correction ($q < 0.05$). For ANC, the exact q-value was 0.0498. Bold indicates statistical significance after FDR correction ($q < 0.05$). Abbreviations: TNSS, total nasal symptom score; IgE, immunoglobulin E; tIgE, total immunoglobulin E; D. *farinae*, Dermatophagoides farinae; D. *pteronyssinus*, Dermatophagoides *pteronyssinus*; WBC, white blood cell; RBC, red blood cell; Hb, hemoglobin; Hct, hematocrit; MCV, mean corpuscular volume; MCH, mean corpuscular hemoglobin; MCHC, mean corpuscular hemoglobin concentration; RDW-SD, red cell distribution width (standard deviation); RDW-CV, red cell distribution width (coefficient of variation); PLT, platelet; MPV, mean platelet volume; PDW, platelet distribution width; P-LCR, platelet-large cell ratio; PCT, plateletcrit; ANC, absolute neutrophil count; ALC, absolute lymphocyte count; AMC, absolute monocyte count; AEC, absolute eosinophil count; ABC, absolute basophil count; NEUT%, neutrophil percentage; LYMPH%, lymphocyte percentage; MONO%, monocyte percentage; EOS%, eosinophil percentage; BASO%, basophil percentage.

Correlations between hematological parameters, inhalant allergen-specific IgE and nasal symptom score

The TNSS was positively correlated with IgA, HCT, RDW-SD, MPV, P-LCR, absolute eosinophil count (AEC), absolute basophil count (ABC), eosinophil percentage (EOS%), basophil percentage (BASO%), total IgE, *Dermatophagoides pteronyssinus*-specific IgE, and *Dermatophagoides farinae*-specific IgE (all $P < 0.05$). The TNSS was negatively correlated with mean corpuscular hemoglobin concentration (MCHC) ($P = 0.004$).

The nasal itching score was positively correlated with RDW-CV, AEC, ABC, EOS%, and total IgE (all $P < 0.05$). The sneezing score was positively correlated with AEC, ABC, EOS%, BASO%, total IgE, D. *pteronyssinus*-specific IgE, D. *farinae*-specific IgE, and dog dander-specific IgE (all $P < 0.05$). The rhinorrhea score was positively correlated with HCT, RDW-SD, AEC, ABC, and EOS% (all $P < 0.05$), and negatively correlated with MCHC ($P = 0.013$). The nasal congestion score was positively correlated with IgA, MPV, P-LCR, total IgE, D. *pteronyssinus*-specific IgE, D. *farinae*-specific IgE, and fungus-specific IgE (all $P < 0.05$). The ocular symptom score was positively

Table 6. Significant correlations between immunological parameters, allergen-specific IgE and nasal symptom scores after FDR correction

Parameter (unit)	TNSS	Nasal itch	Sneezing	Rhinorrhea	Nasal congestion	Eye symptoms
IgA	0.173	0.008	0.053	0.073	**0.328**	0.045
Total IgE	**0.221**	0.134	**0.219**	0.093	0.148	-0.018
ABC ($\times 10^9$/L)	**0.232**	0.139	0.175	0.177	0.093	0.088
EOS%	**0.208**	0.175	0.184	0.160	0.038	0.169

Notes: Spearman's rank correlation analysis was performed (n = 253). Data are Spearman's correlation coefficients (*r*). Bold indicates statistical significance after FDR correction (q < 0.05) using the Benjamini-Hochberg procedure. Only parameters with at least one significant correlation (q < 0.05) are shown. The complete correlation matrix, including raw *p*values and FDRadjusted qvalues, is available in Table S1. Abbreviations: TNSS, total nasal symptom score; IgE, immunoglobulin E; ABC, absolute basophil count.

correlated with AEC and EOS% (all $P < 0.05$). After false discovery rate correction, only the correlations that remained statistically significant are presented in **Table 6**.

Discussion

Several epidemiological investigations have examined allergen sensitization patterns across China. Notably, Li et al. conducted skin prick test (SPT) evaluations among asthma and/or rhinitis patients, revealing significant geographic variations in sensitization profiles [10]. While regional variations in allergen prevalence were observed across study centers, HDM remain the predominant sensitizing agents among Chinese AR patients. Notably, sensitization rates to pet-derived allergens (cat/dog dander) and Humulus pollen have demonstrated marked upward trends during the past decade [11]. Consistent with previous findings, our study identified D. *pteronyssinus* and D. *farinae* as the predominant aeroallergens among pediatric AR patients in Guangzhou.

A global meta-analysis reveals that prevalence patterns undergo a marked transition from male predominance in childhood (peaking at puberty) to consistent female predominance in post-pubertal stages [12]. Emerging evidence implicates sex hormone fluctuations, specifically elevated estrogen and progesterone levels during and after adolescence, as key mediators of the sexual dimorphism observed in allergic disease prevalence through their immunomodulatory effects [13]. Sex-based stratification of our cohort (male-to-female ratio > 2:1) revealed pronounced immunological differences, with male subjects exhibiting markedly increased tIgE, D. *farinae*-sIgE, German cockroach-sIgE, IgA, and complement C4 levels. This comprehensive biomarker profile indicates enhanced atopic predisposition in male pediatric patients. Regarding age, we found that school-age children had longer disease duration, greater disease severity, and higher sensitization rates to D. *farinae* and D. *pteronyssinus*, underscoring the importance of early prevention and management of AR.

In univariate analysis, we found that AEC and EOS% were negatively associated with disease duration. However, after adjusting for age and sex in multivariable regression analysis, these associations were no longer significant (Table S2), suggesting that the observed differences in eosinophil parameters may be confounded by age-related immune maturation rather than being independently driven by disease duration. Both eosinophil count and eosinophil percentage were positively correlated with symptom score, suggesting that they can be used as predictors for disease severity. Consistent with our findings, seasonal allergen exposure in AR patients has been associated with increased peripheral eosinophil levels, which parallel worsening of clinical symptoms and nasal inflammatory responses [14]. Furthermore, HDM-sensitized AR patients exhibit elevated eosinophil percentages after allergen challenge, though this response is less pronounced than that observed in allergic asthma [15].

Notably, our analysis identified basophil parameters (both count and percentage) as potential predictors of clinical symptom severity. Allergen challenge in AR patients induces basophil recruitment to nasal mucosal tissues, with subsequent histamine secretion reaching maximal levels at the 11-hour time point [16].

While studies on allergic asthma report decreased circulating basophils (likely due to airway recruitment during late-phase responses), findings regarding basophil levels in AR have been inconsistent [17].

Our data showed that neutrophil percentage was significantly higher in boys, older children, and those with longer disease duration, implying that neutrophils may be correlated with disease severity. Multivariable regression analysis, however, revealed that neutrophil percentage was not independently associated with disease duration after accounting for age and sex (Table S2), indicating that the apparent relationship is likely attributable to age-related changes. In AR, late-phase inflammatory responses trigger both peripheral neutrophil activation and significant neutrophilic infiltration in nasal secretions, peaking at 6 hours post-allergen challenge [18]. Research by Arebro et al. revealed elevated neutrophil counts in allergic individuals compared to healthy subjects, as observed in peripheral blood during pollen season. These activated neutrophils may play a role in AR-related allergic inflammation by stimulating T-cell responses and recruiting eosinophils [19].

Comparative studies indicate that AR patients exhibit significantly increased circulating monocyte counts compared with non-allergic control subjects [20]. Moniuszko et al. observed distinct monocyte phenotype profiles between AR patients and non-atopic control subjects [21]. Among our pediatric cohort, we observed distinct sexual dimorphism in monocyte profiles, with male participants demonstrating elevated absolute monocyte counts compared to female peers.

We found that MPV and P-LCR values were positively correlated with TNSS in our cohort. Current understanding of platelet dynamics during allergen exposure in AR remains incomplete; however, existing evidence has confirmed a relationship between elevated IgE levels and impaired platelet aggregation [22]. Further studies are required to elucidate the association between MPV and P-LCR parameters.

Studies have documented erythrocytopenia during the initial stages of allergic immune activation in AR [23]. Similarly, our data revealed a statistically significant positive association between HCT, RDW-SD, and TNSS.

Our immunological profiling identified serum total IgE and eosinophil percentage as reliable biomarkers for disease severity assessment, with IgA levels also demonstrating a significant association with nasal congestion score but not with total symptom score. In contrast to the findings for eosinophils and neutrophils, multivariable regression analysis adjusting for age and sex revealed that serum IgA levels remained significantly associated with longer disease duration (Table S2). This suggests that IgA may reflect cumulative antigenic exposure or chronic mucosal immune activation in pediatric AR. Supporting this finding, Rama et al. observed significantly elevated total IgE levels in AR patients compared with both non-AR and healthy control groups [24]. IgA exhibits distinct molecular forms depending on its location-circulating as monomers in serum while adopting secretory complexes in external secretions [25]. Studies indicate a selective upregulation of IgA in mucosal secretions (salivary/nasal) but not in systemic circulation among AR patients [26].

Conclusion

In sum, our study confirms that HDM are the predominant allergens in pediatric AR in Guangzhou. It identifies significant sex-based (male predominance in sensitization/immune markers), age-related (increased severity/sensitization in school-age), and disease duration-associated immunological differences. Key hematological parameters (eosinophils, basophils, neutrophils, platelets) and immunoglobulins (tIgE, HDM-sIgE, IgA) correlate with symptom severity, highlighting their potential as biomarkers for assessing AR severity and guiding targeted management strategies in children. Notably, after adjusting for age and sex, serum IgA emerged as an independent marker associated with longer disease duration, suggesting its potential role as a marker of cumulative allergic inflammation.

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Disclosure of conflict of interest

None.

Address correspondence to: Jing Ma, Department of Otolaryngology, Head and Neck Surgery, Kunming Children's Hospital, Kunming, Yunnan, China. Tel: +86-13751872495; E-mail: majingkch@sina.com; Wenlong Liu, Department of Otolaryngology, Guangzhou Women and Children's Medical Center, Guangzhou Medical University, Guangzhou 510623, Guangdong, China. Tel: +86-13751872495; E-mail: lwl20103@163.com

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Table S1. Complete correlations between hematological parameters, allergen-specific IgE and nasal symptom scores

Parameter	Statistic	TNSS	Nasal itch	Sneezing	Rhinorrhea	Nasal congestion	Eye symptoms
IgG	*r*	0.012	-0.048	-0.002	0.022	0.029	-0.021
	p	0.846	0.450	0.969	0.722	0.650	0.742
	q	0.938	0.816	0.982	0.903	0.884	0.904
IgA	*r*	0.173	0.008	0.053	0.073	0.328	0.045
	p	0.006	0.900	0.402	0.249	< 0.001	0.474
	q	0.088	0.949	0.784	0.607	**0.006**	0.828
IgM	*r*	-0.032	0.027	-0.107	0.010	0.008	-0.115
	p	0.612	0.668	0.089	0.880	0.893	0.068
	q	0.879	0.888	0.341	0.953	0.950	0.325
C3	*r*	-0.114	-0.083	-0.026	-0.079	-0.046	-0.018
	p	0.071	0.190	0.683	0.209	0.467	0.781
	q	0.332	0.505	0.873	0.537	0.828	0.918
C4	*r*	-0.100	-0.045	-0.031	-0.091	-0.060	-0.068
	p	0.113	0.480	0.629	0.149	0.344	0.283
	q	0.389	0.826	0.892	0.441	0.712	0.637
WBC	*r*	0.026	-0.002	0.013	0.040	0.027	-0.005
	p	0.676	0.969	0.840	0.525	0.667	0.941
	q	0.879	0.986	0.936	0.859	0.897	0.979
RBC	*r*	0.117	0.029	0.057	0.096	0.100	0.073
	p	0.064	0.643	0.366	0.126	0.111	0.247
	q	0.319	0.896	0.751	0.421	0.388	0.608
Hb	*r*	0.087	0.039	0.048	0.106	0.068	0.074
	p	0.168	0.534	0.446	0.093	0.284	0.240
	q	0.462	0.844	0.815	0.340	0.633	0.604
Hct	*r*	0.173	0.080	0.089	0.187	0.107	0.069
	p	0.006	0.205	0.159	0.003	0.088	0.275
	q	0.083	0.533	0.454	0.078	0.343	0.625
MCV	*r*	0.022	0.042	0.027	0.070	-0.051	-0.026
	p	0.731	0.510	0.670	0.271	0.418	0.676
	q	0.900	0.840	0.886	0.628	0.782	0.874
MCH	*r*	-0.095	-0.052	-0.003	-0.043	-0.106	-0.022
	p	0.133	0.411	0.962	0.501	0.091	0.733
	q	0.426	0.776	0.992	0.843	0.343	0.898
MCHC	*r*	-0.179	-0.109	-0.044	-0.156	-0.117	0.029
	p	0.004	0.084	0.491	0.013	0.064	0.647
	q	0.094	0.339	0.833	0.122	0.312	0.885
RDW-SD	*r*	0.133	0.121	0.094	0.134	0.010	-0.040
	p	0.034	0.055	0.137	0.033	0.880	0.525
	q	0.221	0.299	0.427	0.227	0.949	0.853
RDW-CV	*r*	0.119	0.128	0.122	0.050	-0.023	-0.032
	p	0.058	0.041	0.053	0.430	0.714	0.616
	q	0.302	0.240	0.295	0.799	0.898	0.879
PLT	*r*	-0.045	-0.033	-0.018	-0.052	-0.011	-0.120
	p	0.479	0.599	0.771	0.407	0.859	0.057
	q	0.830	0.871	0.920	0.774	0.944	0.303

PDW	*r*	0.040	0.039	-0.015	-0.016	0.066	0.114
	p	0.527	0.541	0.816	0.805	0.295	0.071
	q	0.850	0.850	0.936	0.933	0.651	0.326
MPV	*r*	0.144	0.024	0.036	0.110	0.169	0.110
	p	0.022	0.704	0.569	0.080	0.007	0.081
	q	0.178	0.890	0.865	0.334	0.082	0.333
P-LCR	*r*	0.147	0.035	0.034	0.113	0.164	0.110
	p	0.019	0.581	0.592	0.072	0.009	0.079
	q	0.171	0.872	0.866	0.324	0.096	0.336
PCT	*r*	0.033	-0.030	0.027	0.014	0.061	-0.090
	p	0.603	0.636	0.673	0.825	0.337	0.153
	q	0.871	0.897	0.885	0.937	0.710	0.442
ANC	*r*	0.011	-0.044	0.003	0.008	0.055	-0.069
	p	0.867	0.481	0.966	0.900	0.380	0.274
	q	0.944	0.822	0.991	0.944	0.760	0.629
AMC	*r*	0.062	0.085	-0.029	0.081	0.035	0.048
	p	0.325	0.180	0.647	0.197	0.578	0.445
	q	0.698	0.490	0.891	0.518	0.873	0.820
ALC	*r*	0.040	0.009	0.019	0.042	0.040	0.027
	p	0.528	0.887	0.768	0.505	0.529	0.667
	q	0.846	0.948	0.922	0.838	0.842	0.892
AEC	*r*	0.173	0.163	0.147	0.139	0.011	0.143
	p	0.006	0.010	0.020	0.027	0.860	0.023
	q	0.078	0.102	0.167	0.197	0.940	0.179
ABC	*r*	0.232	0.139	0.175	0.177	0.093	0.088
	p	< 0.001	0.027	0.005	0.005	0.139	0.164
	q	**0.023**	0.204	0.084	0.078	0.428	0.457
NEUT%	*r*	-0.015	-0.052	-0.009	-0.017	0.022	-0.083
	p	0.813	0.407	0.886	0.785	0.723	0.188
	q	0.937	0.781	0.951	0.918	0.900	0.506
MONO%	*r*	0.047	0.109	-0.026	0.042	0.014	0.095
	p	0.460	0.085	0.679	0.503	0.830	0.132
	q	0.828	0.337	0.873	0.841	0.934	0.429
LYMPH%	*r*	-0.034	-0.014	-0.018	-0.016	-0.028	0.025
	p	0.590	0.828	0.775	0.801	0.657	0.691
	q	0.868	0.936	0.916	0.933	0.889	0.879
EOS%	*r*	0.208	0.175	0.184	0.160	0.038	0.169
	p	0.001	0.005	0.003	0.011	0.543	0.007
	q	**0.047**	0.090	0.100	0.107	0.847	0.078
BASO%	*r*	0.133	0.106	0.171	0.061	-0.014	0.117
	p	0.034	0.093	0.006	0.337	0.823	0.062
	q	0.215	0.345	0.074	0.717	0.939	0.315
NLR	*r*	0.013	-0.020	0.007	-0.003	0.038	-0.046
	p	0.834	0.757	0.917	0.960	0.553	0.471
	q	0.934	0.918	0.958	0.994	0.857	0.829
PLR	*r*	-0.071	-0.036	-0.034	-0.065	-0.057	-0.098
	p	0.263	0.568	0.586	0.303	0.370	0.118
	q	0.622	0.869	0.873	0.663	0.753	0.400

Total IgE	*r*	0.221	0.134	0.219	0.093	0.148	-0.018
	p	< 0.001	0.033	< 0.001	0.140	0.019	0.772
	q	**0.012**	0.234	**0.008**	0.425	0.165	0.917
D. *pteronyssinus*	*r*	0.182	0.089	0.180	0.078	0.134	-0.002
	p	0.004	0.160	0.004	0.219	0.033	0.976
	q	0.085	0.451	0.078	0.557	0.221	0.984
D. *farinae*	*r*	0.186	0.071	0.185	0.112	0.131	0.053
	p	0.003	0.257	0.003	0.075	0.038	0.403
	q	0.117	0.614	0.088	0.325	0.228	0.779
Cat dander	*r*	0.095	-0.029	0.113	0.070	0.055	0.047
	p	0.132	0.647	0.073	0.270	0.383	0.460
	q	0.435	0.896	0.322	0.632	0.760	0.822
Dog dander	*r*	0.090	0.012	0.133	0.054	0.027	0.073
	p	0.152	0.855	0.035	0.390	0.673	0.244
	q	0.445	0.944	0.216	0.767	0.880	0.607
German cockroach	*r*	0.072	0.063	0.100	-0.003	0.008	0.001
	p	0.254	0.317	0.111	0.966	0.897	0.986
	q	0.613	0.687	0.394	0.987	0.950	0.990
Weed pollen	*r*	0.060	0.055	0.103	0.000	0.036	-0.022
	p	0.339	0.380	0.104	0.998	0.567	0.729
	q	0.708	0.767	0.374	0.998	0.873	0.903
Fungi	*r*	0.095	0.019	0.092	0.029	0.126	-0.034
	p	0.133	0.767	0.143	0.642	0.046	0.589
	q	0.421	0.925	0.429	0.900	0.263	0.872

Notes: *r*: Spearman's correlation coefficient. *p*: raw *p*-value. *q*: FDR-adjusted *p*-value (Benjamini-Hochberg). Bold indicates statistical significance after FDR correction (q < 0.05). All correlations were calculated on 253 subjects. Abbreviations: TNSS, total nasal symptom score; IgE, immunoglobulin E; tIgE, total immunoglobulin E; D. *farinae*, Dermatophagoides farinae; D. *pteronyssinus*, Dermatophagoides *pteronyssinus*; WBC, white blood cell; RBC, red blood cell; Hb, hemoglobin; Hct, hematocrit; MCV, mean corpuscular volume; MCH, mean corpuscular hemoglobin; MCHC, mean corpuscular hemoglobin concentration; RDW-SD, red cell distribution width (standard deviation); RDW-CV, red cell distribution width (coefficient of variation); PLT, platelet; MPV, mean platelet volume; PDW, platelet distribution width; P-LCR, platelet-large cell ratio; PCT, plateletcrit; ANC, absolute neutrophil count; ALC, absolute lymphocyte count; AMC, absolute monocyte count; AEC, absolute eosinophil count; ABC, absolute basophil count; NEUT%, neutrophil percentage; LYMPH%, lymphocyte percentage; MONO%, monocyte percentage; EOS%, eosinophil percentage; BASO%, basophil percentage.

Table S2. Multivariable regression analysis of laboratory parameters associated with disease duration (continuous), adjusted for age and sex

Dependent variable	n	B (95% CI) per year increase in disease duration	Standardized β	*P* value	Adjusted R^2
IgA (g/L)	253	0.012 (-0.041 to 0.065)	0.04	0.664	0.103
AEC (×10^9/L)	253	-0.008 (-0.032 to 0.016)	-0.05	0.487	-0.003
EOS%	253	-0.157 (-0.433 to 0.119)	-0.09	0.268	-0.006
P-LCR (%)	253	0.030 (-0.434 to 0.494)	0.01	0.901	0.052
C4 (g/L)	253	-0.003 (-0.007 to 0.001)	-0.11	0.163	0.016
NEUT%	253	-0.482 (-1.196 to 0.232)	-0.10	0.185	0.078
Cat dander sensitization	253	OR = 1.305 (1.064 to 1.601)	-	0.011	-

Note: Continuous variables were analyzed using linear regression; cat dander sensitization was analyzed using binary logistic regression. All models were adjusted for age (continuous) and sex (male = 0, female = 1). B, unstandardized regression coefficient; β, standardized regression coefficient; CI, confidence interval; OR, odds ratio; Adjusted R^2, adjusted R-squared for linear regression models.