Journal of Biosciences and Medicines, 2024, 12, 40-54
https://www.scirp.org/journal/jbm
ISSN Online: 2327-509X
ISSN Print: 2327-5081

Analysis of *in Vitro* Detection of Allergens in 3901 Children with Allergic Rhinitis in Shenzhen Area

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How to cite this paper: Wu, B., Yang, W.K., Huang, C.F. and Xu, Q. (2024) Analysis of *in Vitro* Detection of Allergens in 3901 Children with Allergic Rhinitis in Shenzhen Area. *Journal of Biosciences and Medicines*, **12**, 40-54.
https://doi.org/10.4236/jbm.2024.1212004

Received: October 20, 2024
Accepted: November 29, 2024
Published: December 2, 2024

Abstract

Background: Allergic rhinitis (AR) is a common allergic disease in children, characterized by an immune response to various environmental and food allergens. The distribution and prevalence of allergen-specific IgE (sIgE) play a crucial role in understanding the pathophysiology and management of AR. In Shenzhen, the profile of common allergens in children with AR has not been extensively studied, particularly in relation to seasonal variations, gender, and age differences. **Objective:** To investigate the distribution of allergen-specific IgE (sIgE) in children with allergic rhinitis (AR) in Shenzhen, focusing on 28 allergens. **Methods:** A total of 3901 children with AR, aged 0 to 14 years, were selected from the outpatient clinic of Longgang District Maternal and Child Health Hospital. The distribution of sIgE positivity across 28 allergens was compared by season, gender, and age group. **Results:** Among inhalant allergens, the three most common with the highest positive rates were house dust mites, dog dander, and cat dander. In the food allergen group, the top three were milk, egg white, and beef. Dust mites exhibited the highest positive rate across all four seasons. Statistically significant differences ($P < 0.05$), were observed for dust mites, cat dander, cockroach, tree pollen, house dust, grass, egg white, beef, shellfish, cod, and mutton. Positive distribution patterns varied by gender for dust mites, cockroaches, tree pollen, house dust, and mugwort ($P < 0.05$), and by food allergens such as shrimp, crab, lobster/scallop, and mutton ($P < 0.05$). The prevalence of house dust mites, cat dander, and cockroaches increased with age, while the positive rate of dog dander decreased with age ($P < 0.01$). Similarly, milk and egg white sensitization rates declined with age ($P < 0.05$). Notably, milk continued to show a relatively high positive rate after 3 years of age, with a higher proportion of strong positive sensitization. **Conclusion:** House dust mites and dog dander are the most prevalent inhalant allergens for children with AR across all seasons, genders, and age groups in Shenzhen. Milk and egg white are the primary food allergens. The positive rate for inhalant allergens generally increases with age, while food allergens such as milk and egg white show a decreasing trend. Milk retains a relatively higher positive rate beyond 3 years of age, accompanied by a higher proportion of strong positive sensitization.

Keywords

Shenzhen, Allergic Rhinitis, Children, Allergen Specific IgE

1. Introduction

The rapidly increasing prevalence of allergic rhinitis (AR), allergic asthma, and other allergic diseases in children has attracted global attention. The International Study of Asthma and Allergic Rhinitis in Children (ISAAC) [1] reported that the prevalence of AR in children aged 6 - 7 years was 8.5%, and 14.6% in those aged 13 - 14 years, with significant regional and international variations. Epidemiological studies in various regions of China indicate that the prevalence of AR in children ranges from 18.10% to 49.68%, with confirmed prevalence rates between 10.80% and 21.09%, showing an increasing trend [2]-[4]. The onset of AR is closely related to environmental factors, and the types of allergens differ by region. In northern China (including north-western and north-eastern areas), weed pollen is the primary allergen [5]-[7], whereas in the southern regions (East, Central, and South China), dust mites and house dust mites are the predominant allergens [7]-[10]. Given China's vast geographical expanse and significant regional variations in environmental, climatic, economic, and hygiene conditions, the composition of allergens varies considerably across different areas [5].

Shenzhen, as a major immigrant city in southern China, has a diverse population that includes both northern and southern migrants, resulting in a complex distribution of allergens. However, to date, no studies have reported the distribution of allergen-specific IgE (sIgE) in children with AR in this region. Early identification of potential allergens is crucial for clinicians and parents, as it provides a basis for developing more effective and safer prevention and treatment strategies for AR. The diagnosis of IgE-mediated allergic diseases relies on both *ex vivo* and *in vivo* testing of allergen extracts to detect sensitization to specific allergens, with the final diagnosis confirmed through correlation with the clinical history [11]. Due to its safety and versatility, including its applicability regardless of age or recent drug use, sIgE testing is a widely used laboratory marker to assess atopic status in children and identify specific allergens to which they may be sensitized. This study reports the analysis of *in vitro* sIgE results for 28 common allergens in 3901 children with AR in Shenzhen, stratified by season, gender, and age group.

2. Methodology and Subjects

2.1. Study Subjects

This study retrospectively analyzed pediatric patients aged 0 - 14 years with allergic rhinitis (AR) admitted to the pediatric outpatient department of Longgang District Maternal and Child Health Hospital in Shenzhen from January 2022 to March 2024. After screening for eligibility, a total of 3901 patients were included. 1) Inclusion Criteria: Children aged 0 - 14 years (*i.e*., from birth to less than 15 years old); All participants must meet the diagnostic criteria for allergic rhinitis as outlined in the 2022 edition of the Diagnosis and Treatment Guidelines for Allergic Rhinitis; All children must have undergone specific allergen IgE (sIgE) Testing; The child's guardian or legal representative must provide written informed consent and agree to participate in this study. 2) Exclusion Criteria: Presence of other allergic diseases, presence of severe chronic diseases, or participation in other interventional studies. Statistical analyses were performed using the Chi-square test to compare differences in proportions among multiple categories. Post-hoc statistical power analysis was conducted using G*Power software, with the significance level (α) set at 0.05. A sample size of 3901 participants was included, with a Cohen's w effect size of 0.3 (medium effect), indicating that this sample size is sufficient to support the validity of hypothesis testing.

2.2. Data Collection Methods

1) Clinical Data: Clinical data, including basic information such as age, sex, and residence, as well as medical history, medication history, and family history, were collected. After obtaining informed consent from the patient's guardian, relevant data were obtained by reviewing the electronic medical record system or consulting with the guardian.

2) sIgE Testing: The test is performed by immunoblotting, and the presence of spots or bands at each specific detection site is considered as positive, with reference to the relationship between the concentration of specific IgE (IU/ml) antibody and the grading standard in the international standard, a positive test result is defined as more than 0.35 IU/ml, a strong positive test result is defined as more than 17.501 U/mL. Internationally, the relationship between specific IgE antibody concentration and grading criteria is: <0.35 IU/ml is considered negative; 0.35 - 0.70 IU/ml is grade 1 (weak positive); 0.71 - 3.50 IU/ml is grade 2 (positive); 3.51 - 17.50 IU/ml is grade 3 (strong positive); 17.51 - 50.0 IU/mlis grade 4 (strong positive); 50.01 - 100.0 IU/ml is grade 5 (very strong positive); >100.0 IU/ml is grade 6 (very strong positive).

2.3. Statistical Analysis

SPSS 26.0 software was used for data processing. For the count data, frequency and percentage were calculated. The χ^2 test was used for group comparisons, with the significance level set at $P < 0.05$. Differences were considered statistically significant.

3. Results

3.1. Clinical Data and Control of Confounding Factors

In this study, we performed chi-square tests to compare the differences in family allergy history, previous allergic history, living environment, and medication history among children with allergic rhinitis (AR) across different age, gender, and seasonal groups. The results indicated that none of these factors showed statistically significant differences across age groups, seasonal groups, or gender groups ($P > 0.05$). This suggests that the study effectively controlled for the potential confounding effects of these variables on the outcomes (See Table 1).

Table 1. Clinical data and control of confounding factor.

	Seasons						Sex				Age				
	Spring (n = 983)	Summer (n = 1206)	Autumn (n = 888)	Winter (n = 824)	χ^2 value	P value	Male (n = 2250)	Female (n = 1651)	χ^2 value	P value	0 to 3 years (n = 771)	3 to 6 years (n = 2093)	6 to14 years (n = 1037)	χ^2 value	P value
Family History of Allergies															
Yes	483 (49.1)	601 (49.8)	437 (49.3)	451 (54.7)			1145 (50.9)	821 (49.7)			389 (50.5)	1008 (48.2)	519 (50.0)		
No	500 (50.9)	605 (50.2)	450 (50.7)	374 (45.3)	7.211	0.065	1105 (49.1)	830 (50.3)	0.514	0.473	381 (49.5)	1085 (51.8)	518 (50.0)	1.732	0.421
History of Previous Allergies															
Yes	500 (50.9)	582 (48.3)	425 (47.9)	412 (49.9)			1075 (47.8)	804 (48.7)			399 (51.8)	1082 (51.7)	524 (50.5)		
No	983 (49.1)	1206 (51.7)	887 (52.1)	825 (50.1)	2.284	0.516	1175 (52.2)	847 (51.3)	0.323	0.570	371 (48.2)	1011 (48.3)	513 (49.5)	0.441	0.802
Long-term Residence															
Yes	508 (51.7)	606 (50.2)	440 (49.6)	418 (50.7)			1112 (49.4)	806 (48.8)			379 (49.2)	1052 (50.3)	499 (48.1)		
No	475 (48.3)	600 (49.3)	447 (50.4)	407 (49.3)	0.866	0.834	1138 (50.6)	845 (51.2)	0.139	0.710	391 (50.8)	1041 (49.7)	538 (51.9)	1.301	0.522
Use of Anti-allergic or Immunosuppressive Medications															
Yes	475 (48.3)	610 (50.6)	481 (54.2)	398 (48.2)			1101 (48.9)	803 (48.6)			380 (49.4)	1017 (48.6)	516 (49.8)		
No	508 (51.7)	596 (49.4)	406 (45.8)	427 (51.8)	1.356	0.727	1149 (51.1)	848 (51.4)	0.033	0.855	390 (50.6)	1076 (51.4)	521 (51.2)	0.413	0.813

In Table 2, a total of 3901 children aged 0 to 14 years with allergic rhinitis (AR) were enrolled in the pediatric outpatient clinic of Longgang District Maternal and Child Health Hospital in Shenzhen, China, from January 2022 to March 2024. Among these, 2250 were male and 1651 were female, resulting in a male-to-female ratio of 1.36. The mean age of the participants was 4.5 ± 3.2 years. Diagnosis of AR was made according to the 2022 guidelines for the diagnosis and treatment of allergic rhinitis in children [12]. The participants were categorized into three age groups: 776 cases in the 0 - 3-year group (infancy and toddlerhood), 2098 cases in the 3 - 6-year group (preschool age), and 1037 cases in the 6 - 14-year group (school-age group).

3.2. Distribution of Allergen Positivity in 3901 Children with Allergic Rhinitis

The number of allergen-positive cases among 3901 children with allergic rhinitis was 2742, accounting for 70.3%. The top three allergens with the highest positive rates in the inhalation group were house dust mite, dog dander, and cat dander, with 1644, 719, and 358 cases, accounting for 42.1%, 18.4%, and 9.2%, respectively. The top three allergens with the highest positive rates in the food group were milk, egg white, and beef, with 1318, 753, and 496 cases, accounting for 33.8%, 19.3%, and 12.7%, respectively, as shown in Table 2, Figure 1 and Figure 2. More children tested positive for compound allergens (see Figure 3). Among them, 1745 (63.6%, n = 2742) tested positive for two or more allergens, 1083 (39.5%, n = 2742) for three or more, and 58 (2.1%, n = 2742) for ten or more.

Table 2. Distribution of allergen positivity in 3901 children with allergic rhinitis.

Items (n = 3901 cases)	Proportion (%)	Items (n = 3901 cases)	Proportion (%)	Items (n = 3901 cases)	Proportion (%)
Dust mites	1644 (42.1)	Tree pollen combination	166 (4.2)	Amaranth	40 (1.0)
Milk	1318 (33.8)	Shellfish	152 (3.9)	Mango	26 (0.7)
Egg white	753 (19.3)	House dust	150 (3.8)	*Humulus lupulus*	25 (0.6)
Dog dander	719 (18.4)	Lobster/Scallop	145 (3.7)	Mulberry tree	25 (0.6)
Beef	496 (12.7)	Peanut	99 (2.5)	Mutton	24 (0.6)
Cat dander	358 (9.2)	Cashew nut	97 (2.5)	*Artemisia argyi*	18 (0.5)
Shrimp	253 (6.5)	Mold combination	85 (2.2)	Salmon	18 (0.5)
Crab	247 (6.3)	Cod	81 (2.1)	Pineapple	3 (0.1)
Cockroach	225 (5.8)	*Ambrosia artemisiifolia*	80 (2.1)		
Mixed grass	187 (4.8)	Soybean	50 (1.3)		

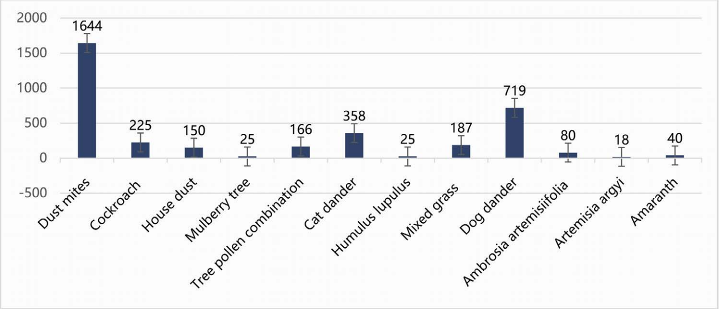

Figure 1. Distribution of allergen positivity in the inhalation group.

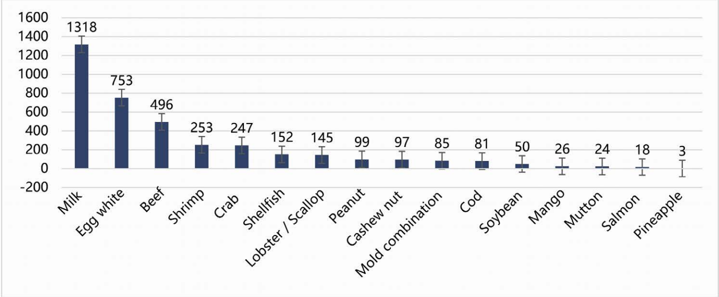

Figure 2. Distribution of allergen positivity in food groups.

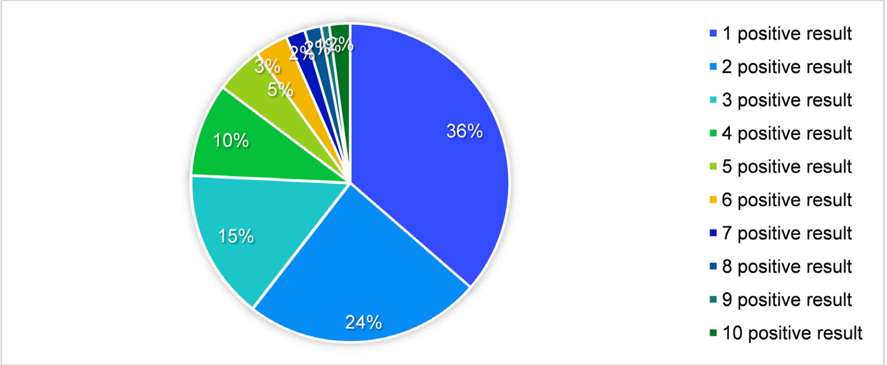

Figure 3. Multiple positive cases of individual allergens.

3.3. Distribution of Allergen Positivity in Different Seasons

The four seasons were defined by temperature: March to May (spring), June to August (summer), September to November (autumn), and December to February (winter). The top four allergens with the highest positivity rates across all seasons were dust mites, milk, egg white, and dog dander (see Table 3, Table 4, and Figure 4 for details). Dust mites had the highest positivity rate across all seasons, peaking at 45.5% in autumn. A statistically significant difference in allergen positivity was observed between the seasons ($P = 0.017$). In addition to dust mites, other allergens with significant seasonal differences ($P < 0.05$) included cat dander, cockroaches, tree pollen, house dust, humus, egg white, beef, shellfish, cod, and mutton.

Table 3. Distribution of allergen positivity in four seasons in the inhalation group.

Items	Spring n = 983	Summer n = 1206	Autumn n = 888	Winter n = 824	X^2 value	P value
Dust mites	384 (39.1)	525 (43.6)	404 (45.5)	331 (40.2)	10.185	0.017
Dog hair	171 (17.4)	226 (18.7)	172 (19.4)	150 (18.2)	1.554	0.670
Cat hair	71 (7.2)	115 (9.5)	78 (8.8)	94 (11.4)	9.774	0.021
Cockroach	37 (3.8)	83 (7.0)	56 (6.3)	49 (5.9)	10.915	0.012
Mixed grass	39 (4.0)	66 (5.5)	42 (4.7)	40 (4.9)	2.703	0.440
Tree pollen	47 (4.8)	72 (6.0)	20 (2.3)	27 (3.3)	20.054	0.000
House dust	22 (2.2)	56 (4.6)	34 (3.9)	38 (4.6)	10.256	0.017
Mold	24 (2.4)	28 (2.3)	19 (2.1)	14 (1.7)	1.330	0.722
Ambrosia artemisiifolia	14 (1.4)	27 (2.2)	17 (1.9)	22 (2.7)	3.788	0.285
Humulus lupulus	1 (0.1)	6 (0.5)	7 (0.8)	11 (1.3)	11.414	0.010
Mulberry tree	8 (0.8)	7 (0.6)	3 (0.3)	7 (0.8)	2.375	0.498
Artemisia argyi	5 (0.5)	9 (0.7)	2 (0.2)	2 (0.2)	4.115	0.249

Table 4. Distribution of allergen positivity in food groups at all seasons.

Items	Spring n = 983	Summer n = 1206	Autumn n = 888	Winter n = 824	X^2 value	P value
Milk	321 (32.7)	414 (34.3)	311 (35.0)	272 (33.0)	1.549	0.671
Egg white	162 (16.5)	293 (24.3)	190 (21.4)	108 (13.1)	47.132	0.000
Beef	78 (7.9)	186 (15.4)	123 (13.9)	109 (13.2)	29.436	0.000
Shrimp	56 (5.7)	90 (74.6)	54 (6.1)	53 (6.4)	3.150	0.369
Crab	59 (6.0)	85 (7.0)	53 (6.0)	50 (6.0)	1.518	0.678
Shellfish	24 (2.4)	59 (4.9)	39 (4.4)	30 (3.6)	9.476	0.024
Lobster	29 (3.0)	49 (4.0)	36 (4.1)	31 (3.8)	2.305	0.512
Peanut	18 (1.8)	40 (3.3)	20 (2.3)	21 (2.5)	5.236	0.155
Cod	9 (0.9)	15 (1.2)	27 (3.0)	30 (3.6)	24.604	0.000
Soybean	14 (1.4)	18 (1.5)	8 (0.9)	10 (1.2)	1.629	0.653
Amaranth	8 (0.8)	13 (1.1)	6 (0.7)	13 (1.6)	4.013	0.260
Mango	6 (0.6)	11 (0.9)	2 (0.2)	7 (0.8)	4.174	0.243
Mutton	0 (0)	10 (0.8)	8 (0.9)	6 (0.7)	8.345	0.039
Salmon	1 (0.1)	4 (0.3)	6 (0.7)	7 (0.9)	6.801	0.079

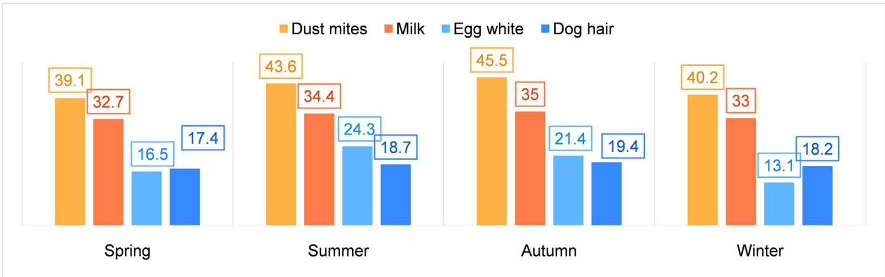

Figure 4. Distribution of the top four allergens with positive rates in all seasons.

3.4. Distribution of Allergen Positivity in Children with Rhinitis of Different Genders

Among the 3901 cases of allergic rhinitis, 2250 were male, of whom 1605 tested positive for allergens, accounting for 71.1%. Of the 1651 female children with allergic rhinitis, 1137 tested positive for allergens, accounting for 68.9%. There was no statistically significant difference between males and females in overall allergen positivity ($P = 0.096$). However, the distribution of positives for specific items was different. In the inhalation group, there were statistically significant differences in the positive distributions of dust mites, cockroaches, tree pollen, house dust, and Artemisia ($P < 0.05$), with males showing higher positivity rates. There were statistically significant differences in the positive distributions of shrimps, crabs, lobsters, scallops, and lamb in the food group (P<0.05), as shown in Table 5 and Table 6.

Table 5. Overall distribution of allergen positivity by gender and distribution of allergen positivity in the inhalation group.

Items	Positive cases	Dust mites	Dog hair	Cat hair	Cockroach	Mixed grass	Tree pollen	House dust	Mold	*Ambrosia artemisiifolia*	*Humulus lupulus*	Mulberry tree	*Artemisia argyi*
Male	1605	991	428	201	150	115	109	108	47	51	14	16	16
Female	1137	655	291	157	75	72	57	42	38	29	11	9	2
χ^2	2.773	7.283	1.235	0.379	7.904	1.174	4.529	13.109	0.202	1.234	0.029	0.412	7.217
P value	0.096	0.006	0.266	0.538	0.005	0.279	0.033	0.000	0.653	0.267	0.865	0.521	0.007

Table 6. Distribution of allergen positivity in different gender food group.

Items	Milk	Egg white	Beef	Shrimp	Crab	Shellfish	Lobster/ Scallop	Peanut	Cashew nut	Cod	Soybean	Amaranth	Mango	Mutton	Salmon
Male	775	430	300	186	180	98	105	66	61	46	33	29	15	19	7
Female	543	323	196	67	67	54	40	33	36	35	17	11	11	5	11
χ^2	0.875	0.201	1.682	27.809	24.948	2.993	13.397	3.362	0.065	0.027	1.437	3.637	0.000	4.568	2.615
P value	0.350	0.654	0.195	0.000	0.000	0.084	0.000	0.067	0.799	0.870	0.231	0.056	0.999	0.033	0.106

3.5. Allergen Test Results of Children with Allergic Rhinitis in Different Age Groups

The positivity rates of the top five allergens among the 12 inhalant allergens exhibited varying trends with age. Specifically, house dust mites, powdery mildew mites, cat dander, and cockroach allergens showed increasing positivity rates with age. In the school-age group, the positivity rate for house dust mites and powdery mildew mites reached 58.1%, with statistically significant differences observed across the three age groups (P < 0.05). In contrast, dog dander had the highest positivity rate during the preschool period, followed by a decrease, with significant differences between the age groups (P< 0.05). The positivity rate for mixed grasses increased during the preschool years, with statistically significant differences across the three age groups (P< 0.05); however, no significant changes were observed after the school-age period, as shown in Table 7.

Table 7. Distribution of 12 inhalant allergen positivity in children with allergic rhinitis in different age groups.

Items	0 to 3 years (n = 771)	3 to 6 years (n = 2093)	6 to14 years (n = 1037)	X^2 value	P value
Dust mites	131 (17.0)	910 (43.5)	602 (58.1)	309.266	0.000
Dog dander	177 (23.0)	391 (18.7)	151 (14.5)	20.923	0.000
Cat dander	57 (7.4)	189 (9.0)	112 (10.8)	6.277	0.043
Cockroach	17 (2.2)	102 (4.9)	106 (10.2)	58.938	0.000

Continued

Mixed grass	28 (3.6)	107 (5.1)	52 (5.0)	2.857	0.240
Tree pollen combination	26 (3.4)	90 (4.3)	50 (4.8)	2.302	0.316
House dust	3 (0.4)	55 (2.6)	92 (8.9)	104.163	0.000
Mold combination	9 (1.2)	51 (2.4)	25 (2.4)	4.616	0.099
Ambrosia artemisiifolia	7 (0.9)	48 (2.3)	25 (2.4)	6.296	0.043
Humulus lupulus	2 (0.3)	11 (0.5)	12 (1.2)	6.540	0.038
Mulberry tree	1 (0.1)	14 (0.7)	10 (1.0)	4.893	0.087
Artemisia argyi	1 (0.1)	8 (0.4)	9 (0.9)	5.863	0.053

Among the 16 food allergens, milk and egg white, which ranked among the top 5 in positivity rate, showed a decreasing trend with age. However, the positivity rate of milk still reached 24.4% in school-age children, with statistically significant differences among the three age groups ($P < 0.05$). In contrast, the distribution of beef, shrimp, and crab showed minimal variation across age groups and was not statistically significant ($P > 0.05$), as shown in Table 8.

Table 8. Distribution of 16 positive food allergens in children with allergic rhinitis in different age groups.

Items	0 to 3 years (n = 771)	3 to 6 years (n = 2093)	6 to14 years (n = 1037)	X^2 value	P value
Milk	297 (38.5)	769 (36.7)	252 (24.3)	57.605	0.000
Egg white	208 (27.0)	434 (20.7)	111 (10.7)	81.141	0.000
Beef	99 (12.8)	281 (13.4)	116 (11.2)	3.148	0.207
Shrimp	51 (6.6)	124 (5.9)	78 (7.5)	2.943	0.230
Crab	52 (6.7)	121 (5.8)	74 (7.1)	2.422	0.298
Shellfish	17 (2.2)	76 (3.6)	59 (5.7)	15.188	0.001
Lobster/Scallop	25 (3.2)	70 (3.3)	50 (4.8)	4.832	0.089
Peanut	16 (2.1)	64 (3.1)	19 (1.8)	5.043	0.080
Cashew nut	13 (1.7)	69 (3.3)	15 (1.4)	12.329	0.002
Cod	9 (1.2)	58 (2.8)	14 (1.4)	10.793	0.005
Soybean	4 (0.5)	33 (1.6)	13 (1.3)	4.992	0.082
Amaranth	4 (0.5)	20 (1.0)	16 (1.5)	4.787	0.091
Mango	1 (0.1)	17 (0.8)	8 (0.8)	4.200	0.122
Mutton	3 (0.4)	14 (0.7)	7 (0.7)	0.804	0.669
Salmon	1 (0.1)	12 (0.6)	5 (0.5)	2.428	0.297
Pineapple	0 (0.0)	1 (0.0)	2 (0.2)	2.639	0.267

3.6. Distribution of Strong Positive Allergens and Above

There were 824 children with strongly positive allergens (grade 4 - 6), accounting for 21.1% of the total. The top 4 inhalant allergens were house dust mites and powder dust mites, 768 cases; dog dander, 30 cases; cat dander, 16 cases; and mixed grass, 12 cases. The top four food allergens were crab, 61 cases; shrimp, 60 cases; lobster and scallop, 38 cases; and milk, 30 cases (see **Table 9** and **Figure 5**).

Table 9. Distribution of strongly positive or higher allergens (top 4) in the inhalation and food groups.

Allergens	Level 4 (%)	Level 5 (%)	Level 6 (%)
Inhalant Allergens			
Dust mites (n = 767)	296 (38.6)	145 (18.9)	326 (42.5)
Dog dander (n = 30)	11 (36.7)	5 (16.7)	14 (46.7)
Cat dander (n = 16)	6 (37.5)	4 (25.0)	6 (37.5)
Mixed grass (n = 12)	5 (41.7)	2 (16.7)	5 (41.7)
Food Allergens			
Crab (n = 61)	30 (49.2)	6 (9.8)	25 (41.0)
Shrimp (n = 60)	30 (50.0)	2 (3.3)	28 (46.7)
Lobster/Scallop (n = 38)	13 (34.2)	8 (21.1)	17 (44.7)
Milk (n = 30)	24 (80.0)	3 (10.0)	3 (10.0)

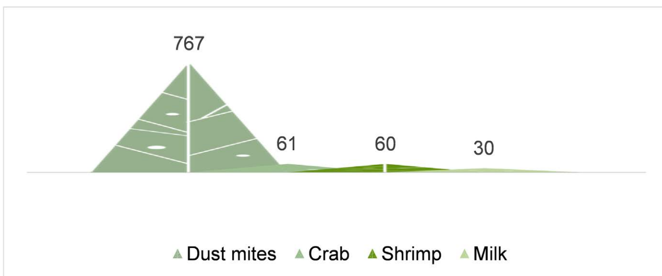

Figure 5. Distribution of the top 4 strongly positive allergens.

4. Discussion

Allergic rhinitis (AR) is a common condition in children and adolescents that significantly affects sleep, school performance, and quality of life. Potential triggers include airborne pollen, moulds, dust mites, and animal dander [13]. Inhalant allergens and food allergens undergo a series of pathophysiological processes to produce allergen-specific IgE (sIgE) [14]-[16]. This sIgE enters the nasal mucosa via the circulatory system and binds to high-affinity IgE receptors (FcεRI) on the surface of local mast cells and basophils, thereby sensitizing the individual. Upon re-exposure to the same allergen, the sensitized organism initiates a cascade of pathological reactions, including vasodilation, increased vascular permeability, exudation of vascular contents, mucus production, sensory nerve stimulation, and the localized aggregation of inflammatory cells in the nasal mucosa. These processes result in the clinical symptoms of AR [17]. The diagnosis of IgE-mediated allergies primarily relies on both *in vivo* and *in vitro* testing of allergen extracts to assess whether there is "sensitization" to specific allergens, followed by confirmation of an "allergy" based on consistency with the patient's clinical history [11]. However, sensitization patterns may vary across different genders, age groups, and seasons. Therefore, exploring the distribution of common allergen positivity, based on these factors, in children with allergic rhinitis is significant for the individualized management and control of AR in different populations.

The number of 3901 children with allergic rhinitis in this study who had allergen positivity amounted to 2742 cases or 70.3%. The top three allergens with the highest positive rates in the inhalation group were house dust mites/powder mites, dog dander, and cat dander. The top three allergens with the highest positive rates in the food group were milk, egg white, and beef. More children were positive for multiple allergens simultaneously. The reasons for this may be related to the underdeveloped immune system in children, which results in immune tolerance and characteristics of cross-sensitization to allergens [18]. Additionally, Shenzhen, with its subtropical climate, provides an environment conducive to the proliferation of dust mites, while the humid air promotes the spread of mold spores. Therefore, in the diagnosis and management of allergic rhinitis, it is essential to consider the impact of multiple allergens and develop personalized prevention and treatment strategies based on the individual characteristics of children.

This study found that dust mites, milk, egg white, and dog dander were the most common allergens across all seasons, with dust mites showing the highest positivity, particularly in autumn (45.5%). Significant seasonal variations were observed for dust mites and several other allergens ($P < 0.05$), but no clear pattern was identified for most allergens. Autumn and winter are the peak seasons for the dispersion of many plant pollens, particularly tree and grass pollens. The release of these allergens coincides with higher humidity and lower temperatures, which facilitate the accumulation of airborne allergens, consistent with findings from previous studies [19]. Additionally, the spread of fungal spores tends to increase during these seasons, as higher humidity levels provide favorable conditions for fungal growth. This observation contrasts with prior research, which may be attributed to the influence of monsoon climates in northern China [20]. Milk and egg proteins are common food allergens in children, which show higher sensitization rates, especially during infancy and early childhood. Moreover, dust mites primarily inhabit human living environments, such as bedding, carpets, and furniture, where mite concentrations tend to fluctuate with seasonal changes, thereby influencing allergen sensitization rates.

Domestic studies have found no significant gender difference in allergen distribution [21]. In this study, the overall allergen positivity rates were 71.1% for males and 68.7% for females, with no significant difference ($P > 0.05$). However, certain allergens, such as dust mites, cockroaches, tree pollen, house dust, wormwood, shrimp, crabs, lobster/scallops, and mutton, showed higher positivity rates in males ($P < 0.05$). Androgens, including testosterone, may enhance immune responses to some extent, leading to a higher sensitivity in males when exposed to allergens. Additionally, females tend to spend more time in domestic environments, where they may be more frequently exposed to indoor allergens like house dust and pet dander. The gender differences in sensitivity to these indoor allergens may not be as pronounced as those observed with outdoor allergens.

A domestic study in Beijing identified the top four inhalant allergens as Candida, Penicillium, Artemisia, and cat dander [22]. In contrast, the present study found that the highest positivity rate was for dust mites, which is a major allergen in children with allergic rhinitis. Previous research in China has reported dust mite sensitization rates as high as 72.8% in children with allergic rhinitis [23]. In this study, the positivity rate for house dust mite/dust mite was 42.1%, with rates increasing by age: 17.0% in the 0 - 3 year age group, 43.5% in the 3 - 6 year group, and 58.1% in the 6 - 14 year group. Similarly, other inhalant allergens, including dog dander, cat dander, cockroaches, house dust, ragweed, and *Humulus lupulus*, also showed a trend of increasing positivity with age. As children age, their immune system gradually establishes immune memory responses, particularly in those over 3 years old, leading to a more pronounced immune reaction to various common allergens, which in turn results in an increase in the positivity rate. Additionally, with the expansion of their activity range, the likelihood of exposure to outdoor allergens also increases.

With the development of China's economy, food choices have become more diverse, and allergic diseases related to food allergies have gained increasing attention. Over the past two decades, the prevalence of milk protein allergy in infants and children in China has risen from 1.6% to 5.7% [24]. Similarly, this study found that the three most common food allergens were milk, egg white, and beef, with positivity rates of 33.8%, 19.4%, and 12.7%, respectively, corresponding to 1322, 758, and 497 cases. These findings indicate that milk remains a major allergen for children with allergic rhinitis. Domestic research suggests that most IgE-mediated milk protein allergies in infants are tolerated by age 3 [25] and our study also observed that the highest milk allergy positivity rate was found in the 0 - 3 year age group, with a decreasing trend as age increased. However, it is noteworthy that even in the 6 - 14 year age group, a significant positive rate of 24.4% was still observed. This is consistent with studies in Europe and the United States [26].

The present study also revealed the distribution of strong positive allergens: 824 or 21.1 per cent were sensitised at level 4 or higher. The house dust mite/dust mite was the most numerous of them, with 768 cases, and accounted for an absolute proportion (93.2%) of the strong positive allergens. Therefore, dust mite desensitisation in children with allergic rhinitis is of great significance, and subcutaneous immunotherapy has been used in the treatment of AR for more than 100 years, which not only significantly improves clinical symptoms, reduces medication usage, and enhances quality of life, but also demonstrates stable long-term efficacy, preventing the progression of AR to asthma and reducing the emergence of new allergens [27]. However, attention needs to be paid to the assessment of efficacy in children who are positive for multiple allergens. The highest rate of strong positivity in the food group was milk, with only 30 cases, but most of them were children after 3 years of age, which suggests that we should consider the degree of sensitisation to milk and the balance of nutritional requirements when guiding the dietary modification of children with milk-sensitised rhinitis, as well as be mindful that although the proportion of children sensitised to milk decreases after the age of 3 years, an increase in children with a high degree of sensitisation may still occur.

5. Conclusion

In summary, house dust mite/dust mite and dog hair dander were the main inhalation allergens in children with allergic rhinitis in Shenzhen, while milk and egg white were the main food allergens. The positivity rate of the major inhalation allergens increased with age, while the positivity rate of food allergens, such as milk and egg white, tended to decrease with age. However, milk may show a higher proportion of strong positive sensitisation in those who continue to have a high rate of positivity after the age of 3 years.

Limitations

1) This study is a single-center retrospective analysis, which only include AR children who presented with allergic symptoms at the hospital and underwent allergen-specific IgE (sIgE) testing, rather than using data from the general population. 2) The study did not consider factors such as the family's socioeconomic status or psychological state, which may limit the ability to establish potential associations between these factors and sensitization to allergens; 3) As this study primarily explores co-sensitization, it does not account for the potential impact of cross-sensitization on the results.

Conflicts of Interest

The authors declare no conflict of interest.

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