European Review for Medical and Pharmacological Sciences 2023; 27: 2751-2758

Allergen detection and logistic multifactor analysis of allergic rhinitis

Y.-L. LIU[1,2], Y.-T. HUO[1], X.-F. PAN[2], X.-H. LIN[2], L.-H. YANG[3], J. GAO[4], W.-H. ZHONG[5]

[1]Department of Otolaryngology, Fujian Maternity and Child Health Hospital, College of Clinical Medicine for Obstetrics & Gynecology and Pediatrics, Fujian Medical University, Fuzhou, China
[2]Department of Otolaryngology, Fujian Children's Hospital, College of Clinical Medicine for Obstetrics & Gynecology and Pediatrics, Fujian Medical University, Fuzhou, China
[3]Department of Otolaryngology-Head and Neck Surgery, Fujian Provincial Hospital, Shengli Clinical Medical College of Fujian Medical University, Fuzhou, China
[4]Department of Medicine and Health, The 900th Hospital of Joint Logistics Support Force of PLA, Fuzhou, China
[5]Department of Clinical Laboratory, Fujian Maternity and Child Health Hospital, College of Clinical Medicine for Obstetrics and Gynecology and Pediatrics, China Medicine for Obstetrics & Gynecology and Pediatrics, Fujian Medical University, Fuzhou, China

Y.-L. Liu and Y.-T. Huo have equally contributed to this project

Abstract. – OBJECTIVE: This study aims to investigate the allergens in children with allergic rhinitis (AR) and AR-related influencing factors.

PATIENTS AND METHODS: The clinical data of 230 children with AR admitted to our hospital from June 2020 to June 2021 were retrospectively analyzed and included in the observation group. The clinical data of 230 healthy children during the same time period were included as the control group. All children had been tested for allergens using serum allergens, and the clinical data were collected by telephone questionnaires. Univariate and multivariate logistic regression were used to analyze the risk factors affecting AR.

RESULTS: A total of 230 children with AR was included in this study, and some of them had two or more allergens. The proportion of house dust mite was the highest among the inhaled allergens, about 75.22%. Shrimp accounted for the highest proportion of food allergens, about 40.87%. Compared with the control group, the proportion of floating population, home heating, allergy history, asthma and other general information in the observation group was higher. At the same time, the proportion of environmental factors such as second-hand smoke, number of residents (≤ 3), daily ventilation and cleaning (no), domestic animals, domestic plants, decoration within 2 years, and living environment (rural) in the observation group was higher. In addition, the proportion of family factors such as delivery mode (cesarean section), family history of allergic rhinitis, parents' education level (middle school and above) in the observation group was higher ($p < 0.05$). Univariate logistic regression analysis showed that allergic history, asthma, second-hand smoke, floating population, number of residents, domestic animals, decoration within 2 years, delivery mode, and family history of allergic rhinitis were the risk factors affecting the incidence of AR in children ($p < 0.05$), and daily window ventilation and cleaning were the protective factors ($p < 0.05$). The multivariate logistic regression analysis showed that asthma, second-hand smoke, floating population, decoration within 2 years, family history of allergic rhinitis and domestic animals were independent risk factors for the occurrence of AR ($p < 0.05$), and daily ventilation and cleaning were protective factors for the occurrence of AR in children ($p < 0.05$).

CONCLUSIONS: The proportion of house dust mite in inhalation allergens and shrimp in food allergens were the highest in AR children. The incidence of AR was closely related to asthma, second-hand smoke, floating population, decoration within 2 years, family history of AR and domestic animals, etc. Targeted measures could effectively prevent the occurrence and recurrence of AR. At the same time, daily ventilation and cleaning were the protective factors which could reduce the incidence and occurrence of AR in children.

Key Words:
Allergic rhinitis, Allergens, Logistic multifactor.

Introduction

Allergic rhinitis (AR) is a non-infectious inflammatory disease of nasal mucosa caused by

Corresponding Author: W.-H. Zhong, MD; e-mail: ham1392000@163.com

abnormal activation of IgE after allergen stimulation[1,2]. There are three necessary conditions for its occurrence, including specific antigens, namely substances that cause the body's immune response, atopic individuals so-called individual differences, and allergies. As one of the most common chronic diseases in pediatrics, AR is accompanied by the clinical symptoms such as sneezing, nasal congestion, nasal itch and watery snot, etc. In severe cases, it may also develop into asthma and allergic rhino conjunctivitis. The complications such as sinusitis, nasal polyps, and otitis media may also occur[3]. AR not only seriously affects the normal life of children, but also brings physical health and cognitive function damage to children, which has become the focus of medical scholars.

AR in children is a multifactorial disease induced by the interaction of genes with the environment, whose risk factors include smog, food, drug allergy history and genetic factors. Allergens are antigens that induce and react with specific IgE antibodies. They are mostly derived from animals, plants, insects, fungi or occupational substances. Its components are proteins or glycoproteins, and very rarely polysaccharides. Allergens are mainly divided into inhaled allergens and food-based allergens. Inhaled allergens are the main cause of allergic rhinitis[4]. At present, the main clinical therapies of AR include etiological treatment combined with anti-allergy medication. Probiotics, such as lactic acid bacteria are also a common way to treat AR[5]. However, if the allergen is uncertain, there may be blind medication and relapse after treatment. Therefore, it is of great significance to determine the allergens of children with AR for guiding the treatment effect and improving the prognosis of children[6,7]. Previous scholars[8,9] have pointed out that prevention is the best way of disease treatment. Identifying the risk factors of AR and reducing the exposure to risk factors are conducive to children's healthy growth and learning. Therefore, analysis of AR related risk factors is essential for reducing the incidence rate of AR.

In this study, the clinical data of 230 children with AR admitted to our hospital from June 2020 to June 2021 were retrospectively analyzed, aiming to examine the allergen detection and influencing factors of AR and further providing guidance for clinical treatment.

Patients and Methods

General Materials

The clinical data of 230 children with AR admitted to our hospital from June 2020 to June 2021 were retrospectively analyzed and included in the observation group. Inclusion criteria: (1) All children met the relevant clinical diagnostic criteria for AR[10], and anterior rhinoscopy confirms AR; (2) Children were tested for serum allergens; (3) The relevant clinical examination data were complete; (4) Children and their family members were informed and had good compliance. They could cooperate with the examination and treatment and signed the informed consent. Exclusion criteria: (1) Children with severe dysfunction in important organs; (2) Children that take immunosuppressant and other drugs which affected allergen detection within 1 month; (3) Children with severe nasal diseases, nasal septum deviation or nasal polyps; (4) Children with moderate to severe asthma; (5) Children with mental disorder or consciousness disorder; (6) Children with abnormal liver and kidney function. The clinical data of 230 healthy children examined at our Regular Physical Examination Center during the same time period were included as the control group. The operation in the present experiment was approved by the Ethics Committee of Fujian Maternity and Child Health Hospital. The process of general data selection was shown in Figure 1.

Outcome Measures

Serum detection: the fasting venous blood of the children in the observation group at the time of the visit with a doctor and the fasting venous blood of the children in the control group at the time of physical examination were collected. After 30 minutes of rest, the venous blood was centrifuged at 3,000 rpm for 10 minutes. The supernatant was carefully collected and stored in the -80°C refrigerator, avoiding repeated freezing and thawing. Inhaled allergens were detected by the UniCAP250 *in vitro* allergen detection system of Pharmacia (Uppsala, Sweden) according to the principle of fluorescent enzyme-linked immunosorbent reaction. The inhalation allergens (house dust mite, ragweed Artemisia, mold combination, animal hair, grass powder combination, common white birch and cockroach) and the food allergens (shrimp, milk, crab, egg white, sesame, nuts, wheat flour, coconut, peanut and soybean) were determined.

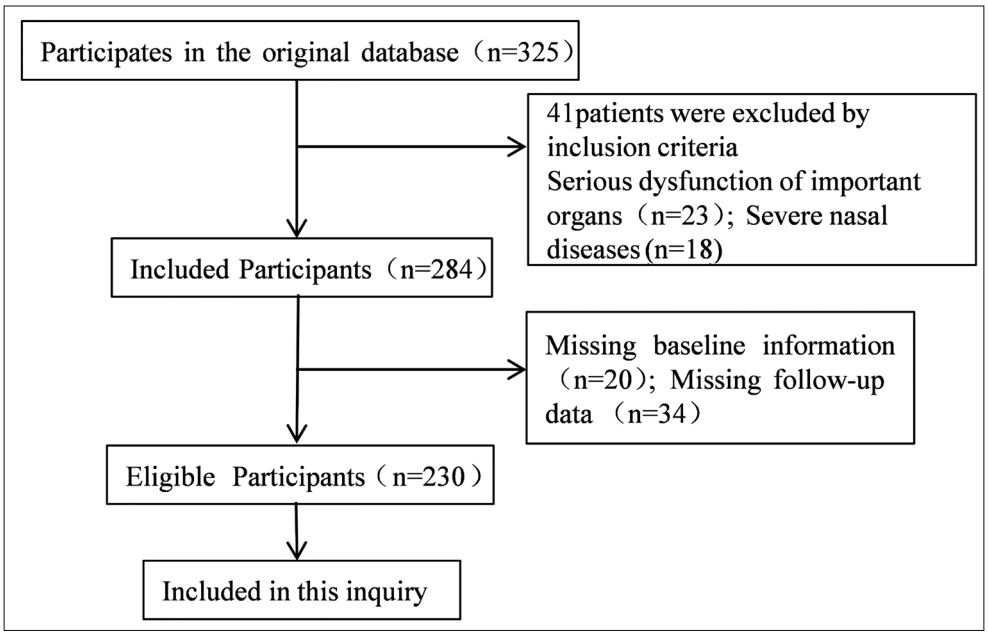

Figure 1. The process of general data selection.

The ovalbumin specific IgE antibody detection kit was purchased from Shanghai Jianglai Biotechnology Co., Ltd. (Shanghai, China) and stored at 2-8°C away from light.

Enzyme linked immunosorbent assay: the frozen sample was dissolved at room temperature, and the standard curve at the concentration of 50, 100, 200 and 400 U/ml was made. 100 μL of serum diluted 100 times was added to each reaction well and incubated at room temperature for 1 h after blocking. After rinsing, 100 μL of horseradish peroxidase labeled IgE antibody was added into the well and was incubated at room temperature for 30 min after blocking. Then, 100 μL of working solution was added into the well and was incubated at room temperature for 30 min after blocking. Afterwards, the termination solution was added and mixed well. The optical density value (OD) of each well was detected by microplate reader at 450 nm, and the specific IgE value > 0.35 U/ml was considered as positive.

Clinical data: the clinical data were collected by telephone questionnaire and were compared between the two groups. The clinical data included the age, gender, breast-feeding, second-hand smoke, floating population, window ventilation and frequent cleaning, heating equipment in the home, residential floor (flat floor, below 10 floors/above), number of residents (≤ 3, 4-5, 6 and above), air conditioning use history, allergy history, family history of allergic rhinitis, contact history with irritating odor, urticaria, other diseases history, asthma, domestic animals, domestic plants, decoration within 2 years, living environment, parents' educational level, nationality, etc.

Statistical Analysis

The experimental data was analyzed using SPSS 20.0 software (IBM Corp., Armonk, NY, USA). The measurement data were expressed in ($\bar{x} \pm s$) and compared by *t*-test; enumeration data was expressed in (%) and compared using χ^2 inspection. The odds ratio (OR) and 95% confidence interval (CI), and adjusted OR and 95% CI of AR were analyzed using univariate and multivariate Logistic regression analysis, and statistically significant variables in univariate analysis were included in multivariate to calculate the adjusted OR value. $p < 0.05$ indicated that the statistical results were statistically significant.

Results

Analysis of Allergens in Children With AR

A total of 230 children with AR was included in this study, and some of them had two or more allergens. The proportion of house dust mite was the highest among the inhaled allergens, about 75.22%. Shrimp accounted for the highest proportion of food allergens, about 40.87% (Table I).

Comparison of Clinical Data

No notable difference was observed between the two groups in age, gender, contact history with irritating odor, urticaria, residential floor, other disease history, nationality, air conditioning use and breast-feeding ($p > 0.05$). The proportion of floating population, home heating, allergy history, asthma and other general information in the observation group was higher compared to the control group. At the same time, the proportion of environmental factors was higher, including second-hand smoke, number of residents ($\leq$ 3), daily ventilation and cleaning (no), domestic animals, domestic plants, decoration within 2 years, and living environment (rural) in the observation group.

In addition, the proportion of family factors in the observation group was higher, such as delivery mode (cesarean section), family history of AR, parents' education level (middle school and above) ($p < 0.05$, Table II, Table III and Table IV).

Univariate Logistic Regression Analysis on Risk Factors of AR

Univariate logistic regression analysis exhibited that allergic history, asthma, second-hand smoke, floating population, number of residents, domestic animals, decoration within 2 years, delivery mode, and family history of AR were the risk factors affecting the incidence of AR in children ($p < 0.05$), and daily window ventilation and cleaning were the protective factors ($p < 0.05$, Table V).

Multivariate Logistic Regression Analysis of Independent Risk Factors For AR

The multivariate logistic regression analysis displayed that asthma, second-hand smoke, floating population, decoration within 2 years, family history of allergic rhinitis and domestic animals were independent risk factors for the occurrence of AR ($p < 0.05$), and daily ventilation and cleaning were protective factors for the occurrence of AR in children ($p < 0.05$, Table VI).

Discussion

AR is a common allergic rhinitis disease in children, with high incidence rate and high recurrence rate. Without timely treatment, serious complications such as sinusitis and otitis media may occurl[1]. With the aggravation of environmental pollution and the decline of human immunity in recent years, the number of patients with AR has gradually increased, which not only seriously affects the study and life of children, but also adversely affects the physical and mental health of children, and also induces large consumption of medical resources[12]. With the rapid development of the medical community in recent years, experimental analysis in mice shows that the probiotic extract LFK of the genus *Enterococcus* may be used as a new targeted drug for the treatment of AR to regulate the IL-12 level of AR mice, but the current research is not mature[13]. Therefore, how to reduce the incidence rate of AR and improve the quality

Table I. Analysis of allergens in children with AR (cases, %).

Specific positive allergen		Cases	Proportion	IgE (IU/mL)
Inhaled allergens	House dust mite	173	75.22%	7.52±2.16
	Artemisia ragweed	83	36.09%	7.23±2.56
	Mold combination	45	19.57%	0.89±0.12
	Animal hair	32	13.91%	2.59±1.45
	Grass powder combination	23	10.00%	0.98±0.06
	Common birch	22	9.57%	1.26±0.23
	Cockroach	18	7.83%	0.98±0.46
Food allergens	Shrimp	94	40.87%	1.53±2.14
	Milk	72	31.30%	0.38±1.24
	Crab	69	30.00%	0.90±0.36
	Egg white	51	22.17%	1.36±2.45
	Sesame	51	22.17%	0.46±1.85
	Nuts	38	16.52%	2.85±2.16
	Wheatmeal	16	6.96%	4.58±3.12
	Coconut	9	3.91%	1.95±2.36
	Peanut	5	2.17%	1.25±2.05
	Soybean	3	1.30%	0.87±1.36

Table II. Comparison of clinical data (cases, %).

Index		The control group (n=230)	The observation group (n=230)	χ^2	*p*
Age	3-6 years old	58 (25.22%)	75 (32.61%)	3.056	0.080
	6-18 years old	172 (74.78%)	155 (67.39%)		
Gender	Male	126 (54.78%)	117 (50.87%)	0.707	0.401
	Female	104 (45.22%)	113 (49.13%)		
Allergy history	Yes	15 (6.52%)	56 (24.35%)	27.997	<0.001
	No	215 (93.48%)	174 (75.65%)		
Contact history with irritating odor	Yes	12 (5.22%)	23 (10.00%)	3.742	0.053
	No	218 (94.78%)	207 (90.00%)		
Urticaria	Yes	25 (10.87%)	39 (16.96%)	3.557	0.059
	No	205 (89.13%)	191 (83.04%)		
Other disease history	Yes	26 (11.30%)	31 (13.48%)	0.501	0.479
	No	204 (88.70%)	199 (86.52%)		
Asthma	Yes	23 (10.00%)	179 (77.83%)	214.801	<0.001
	No	207 (90.00%)	51 (22.17%)		
Nationality	Han nationality	25 (10.87%)	21 (9.13%)	0.387	0.534
	Others	205 (89.13%)	209 (90.87%)		

Table III. Comparison of living environment (cases, %).

Index		The control group (n=230)	The observation group (n=230)	χ^2	*p*
Second-hand smoke	Yes	52 (22.61%)	130 (56.52%)	55.314	<0.001
	No	178 (77.39%)	100 (43.48%)		
Floating population	Yes	30 (13.04%)	68 (29.57%)	18.724	<0.001
	No	200 (86.96%)	162 (70.43%)		
Air conditioning use	Yes	126 (54.78%)	120 (52.17%)	0.315	0.575
	No	104 (45.22%)	110 (47.83%)		
Daily ventilation and cleaning	Yes	152 (66.09%)	121 (52.61%)	8.659	0.003
	No	78 (33.91%)	109 (47.39%)		
Home heating	Yes	88 (38.26%)	124 (53.91%)	11.339	<0.001
	No	142 (61.74%)	106 (46.09%)		
Residential floor	Flat floor	75 (32.61%)	81 (35.22%)	0.550	0.760
	≤10 floor	82 (35.65%)	75 (32.61%)		
	>10 floor	73 (31.74%)	74 (32.17%)		
Number of residents	≤3	65 (28.26%)	91 (39.57%)	7.532	0.023
	4-5	82 (35.65%)	77 (33.48%)		
	≥6	83 (36.09%)	62 (26.96%)		
Domestic animals	Yes	58 (25.22%)	94 (40.87%)	12.734	<0.001
	No	172 (74.78%)	136 (59.13%)		
Domestic plants	Yes	89 (38.70%)	154 (66.96%)	36.857	<0.001
	No	141 (61.30%)	76 (33.04%)		
Decoration within 2 years	Yes	46 (20.00%)	74 (32.17%)	8.839	0.003
	No	184 (80.00%)	156 (67.83%)		
Living environment	City	185 (80.43%)	159 (69.13%)	7.793	0.005
	Village	45 (19.57%)	71 (30.87%)		

of life of children with AR has become the focus of medical scholars.

AR is a result of the interaction of genes and environment. At present, the main clinical treatment of AR is symptomatic treatment, which cannot eradicate symptoms. Once the body contacts the allergen, it can stimulate the recurrence of AR in children[14,15]. Therefore, early identification of children's allergens is one of the important factors to guide the treatment, reduce the recurrence rate and improve the prognosis of patients. A total of 230 children with AR were included in this experiment, and the number of allergen positive cases was 804. The common

Table IV. Comparison of family factors (cases, %).

Index		The control group (n=230)	The observation group (n=230)	χ^2	p
Delivery mode	Cesarean section	121 (52.61%)	146 (63.48%)	5.579	0.018
	Vaginal delivery	109 (47.39%)	84 (36.52%)		
Breast feeding	Yes	184 (80.00%)	172 (74.78%)	1.790	0.181
	No	46 (20.00%)	58 (25.22%)		
Parents' education level	Primary school or no education	66 (28.70%)	39 (16.96%)	9.300	0.010
	Junior high school and senior high school	115 (50.00%)	139 (60.43%)		
	University or above	49 (21.30%)	52 (22.61%)		
Family history of AR	Yes	9 (3.91%)	39 (16.96%)	20.935	<0.001

Table V. Comparison of family factors (cases, %).

Index	β	SE	Wald	p	OR	95% CI
Allergy history	0.725	0.648	1.260	0.018	1.652	2.373-4.715
Asthma	1.850	0.471	10.692	0.001	6.235	2.452-10.358
Second-hand smoke	2.263	0.682	11.371	0.001	7.720	2.537-13.526
Floating population	1.293	0.441	8.572	0.001	3.650	1.525-8.539
Daily ventilation and cleaning	-2.003	0.461	10.972	0.001	0.123	0.051-0.342
Home heating	1.177	0.626	2.418	0.067	1.233	0.929-2.299
Number of residents	0.379	0.213	3.132	0.039	1.724	1.025-2.987
Domestic animals	1.326	0.471	7.573	0.002	3.725	1.425-9.571
Domestic plants	0.460	0.251	2.289	0.070	1.579	0.952-2.590
Decoration within 2 years	1.881	0.568	11.072	0.001	6.751	2.125-13.528
Living environment	0.459	0.261	1.288	0.070	1.571	0.951-2.587
Delivery mode	0.237	0.113	2.479	0.035	1.268	1.012-1.579
Parents' education level	0.152	0.079	1.083	0.081	1.152	0.971-1.387
Family history of AR	1.203	0.415	6.556	0.001	2.342	1.752-8.054

Table VI. Multivariate logistic regression analysis of independent risk factors for AR.

Index	β	SE	Wald	p	OR	95% CI
Asthma	0.779	0.648	4.421	0.015	1.729	1.441-3.725
Second-hand smoke	1.477	0.614	5.752	0.010	4.380	1.312-10.621
Floating population (yes)	1.048	0.415	6.313	0.002	2.841	1.260-6.442
Decoration within 2 years	1.006	0.515	5.960	0.009	4.724	1.012-7.381
Daily ventilation and cleaning	-0.581	0.357	3.505	0.012	0.668	0.542-3.478
Domestic animals	0.237	0.113	3.083	0.017	2.152	0.972-3.379
Family history of AR	1.011	0.708	6.050	0.005	2.041	1.812-5.379

allergens in inhalation allergens included house dust mite, Artemisia tarragon combined with mold, which was similar to the results of Campo et al[16]. The above results suggested that the living environment had a great impact on the occurrence of AR. Strengthening the sanitary conditions of the living environment and regularly removing mites and dust are of good help to children's life health and quality of life. This experiment found that shrimp, milk and nuts accounted for a large proportion of ingested allergens, which indicated that common food may lead to allergy. The food source of children should be fixed in brand and food mode. At the same time, food source allergy

may also be related to food tolerance of different age groups. Therefore, children's dietary sources should be fixed in brand and food methods to reduce the occurrence of AR.

AR is a familial aggregation disease, and the presence of AR history or allergic history such as asthma in both parents may increase the risk of AR in children[17,18]. Okubo et al[19] showed that the probability of a child suffering from AR was as high as 75% in the case of his parents suffered from allergic diseases. Environment is one of the important factors of AR. Early studies[15,20] have found that second-hand smoking during pregnancy can lead to DNA methylation in newborns and greatly increase the probability of allergy. At the same time, nicotine can increase the body's atopy and the incidence of AR by changing the immune response and damaging the nasal epithelium. Finding the allergens of AR and analyzing the risk of AR is of great significance to reduce the incidence rate of AR and improve the quality of life of children with AR. This study showed that asthma, second-hand smoke, floating population, decoration within 2 years, family history of AR and domestic animals were the independent risk factors affecting the incidence of AR, and daily ventilation and cleaning could reduce the risk of AR. It may be because dust mites are easy to breed in indoor, in humid and closed environment and textiles, thus leading to the occurrence of AR. The environment shall be kept clean by opening windows for ventilation and cleaning regularly, so as to reduce the content of dust mites and molds. Tham et al[21] considered that there was a difference in the prevalence of allergy between immigrants and local born subjects living in the same geographical location. The age of migration and length of residence in the host country also affect a person's atopic risk. Second-hand smoke invasion is also an important factor affecting the incidence of AR. Kim et al[22] found that children living in multi-unit houses might be exposed to the second-hand smoke transferred from adjacent units. Compared with children without second-hand smoke invasion, children living in families with second-hand smoke invasion (no more than once a month or more than once a month) are more likely to develop asthma, rhinitis and eczema. Therefore, taking targeted measures according to risk factors can effectively prevent the occurrence and recurrence of AR, which is helpful to improve the quality of life of children.

Previous studies[23] have believed that window ventilation may effectively use sunlight and ultraviolet rays in the air to kill mites and other microorganisms, avoid the breeding of mites and mold, remove harmful gases in indoor air, and breathe fresh air with more ventilation, which can improve the body's immunity and reduce respiratory diseases. Frequent cleaning can not only remove garbage and microorganisms and keep the room clean and tidy, but also help exercise and improve the body's immunity. The results of this study showed that daily window ventilation and cleaning could reduce the risk of allergic rhinitis. The analysis of related reasons may be due to the humid climate, dust mites are easy to multiply indoors, humid closed environments and textiles, resulting in the occurrence of allergic rhinitis. By opening windows daily for ventilation and cleaning to ensure a clean environment, dust mites and mold can be reduced.

Limitations

However, this study still has certain limitations. Due to the limitation of time and sample size, the sample size is from a single source. Moreover, this experiment is a retrospective study, and the selection difference may have some impact on the research results. In addition, this study lacks long-term follow-up, thus it is still necessary to select children in different regions for multi-unit and longitudinal research to comprehensively understand the epidemiology of AR, so as to carry out more accurate diagnosis, treatment and prevention of AR, and provide a more effective and reliable scientific basis for the prevention and treatment of AR.

Conclusions

In general, the proportion of house dust mite in inhalation allergens and shrimp in food allergen were the highest in AR children. The incidence of AR was closely related to asthma, second-hand smoke, floating population, decoration within 2 years, family history of AR and domestic animals, etc. At the same time, daily window ventilation and cleaning can be protective factors for children with AR and reduce the incidence of children with AR. In the health education of children with AR, we should pay attention to children's living environment and avoid common allergens. It is necessary to strengthen the publicity of the cleanliness of the family living environment and pay attention to the reasonable diet structure to effectively prevent the occurrence and recurrence of AR.

Ethics Approval
The operation in the present experiment was approved by the Ethics Committee of Fujian Maternity and Child Health Hospital (2022YJ038).

Informed Consent
The written informed consents were obtained from patients.

Authors' Contributions
Y.-L. Liu and Y.-T. Huo edited the manuscript and performed the experiment. X.-F. Pan collected data. X.-H. Lin and L.-H. Yang processed the data and the statistics. J. Gao gave the support of everything we need. W.-H. Zhong designed the research, provided critical comments and revised the manuscript. All authors contributed to the article and approved the submitted version.

ORCID ID
W.-H. Zhong: 0000-0001-8993-0463

Funding
No funding was received for this paper.

Conflict of Interests
The authors declare that they have no competing interests.

Availability of Data and Materials
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

References

1) Siddiqui ZA, Walker A, Pirwani MM, Tahiri M, Syed I. Allergic rhinitis: diagnosis and management. Br J Hosp Med (Lond) 2022; 83: 1-9.
2) Azizli E, Dilber M. Do products containing menthol exacerbate allergic rhinitis? A narrative review. Eur Rev Med Pharmacol Sci 2022; 26: 61-64.
3) Blaiss MS. Pediatric allergic rhinitis: physical and mental complications. Allergy Asthma Proc 2008; 29: 1-6.
4) Marshall GD Jr. Allergic rhinitis: Localized disease with systemic implications. Ann Allergy Asthma Immunol 2021; 127: 155-156.
5) Wang MF, Lin HC, Wang YY, Hsu CH. Treatment of perennial allergic rhinitis with lactic acid bacteria. Pediatr Allergy Immunol 2004; 15: 152-158.
6) Agnihotri NT, McGrath KG. Allergic and nonallergic rhinitis. Allergy Asthma Proc 2019; 40: 376-379.
7) Ciprandi G, Tosca MA. House dust mites-driven allergic rhinitis: could its natural history be modified. Expert Rev Clin Immunol 2021; 17: 109-114.
8) Meng Y, Wang C, Zhang L. Recent developments and highlights in allergic rhinitis. Allergy 2019; 74: 2320-2328.
9) Cox L. Approach to patients with allergic rhinitis: Testing and treatment. Med Clin North Am 2020; 104: 77-94.
10) Brown T. Diagnosis and management of allergic rhinitis in children. Pediatr Ann 2019; 48: e485-e488.
11) Prieto A, Rondón C, Eguiluz-Gracia I, Muñoz C, Testera-Montes A, Bogas G, Nuñez Cuadros E, Campo P, Torres MJ. Systematic evaluation of allergic phenotypes of rhinitis in children and adolescents. Pediatr Allergy Immunol 2021; 32: 953-962.
12) Zhang Y, Lan F, Zhang L. Advances and highlights in allergic rhinitis. Allergy 2021; 76: 3383-3389.
13) Van Nguyen T, Piao CH, Fan YJ, Shin DU, Kim SY, Song HJ, Song CH, Shin HS, Chai OH. Anti-allergic rhinitis activity of α-lipoic acid via balancing Th17/Treg expression and enhancing Nrf2/HO-1 pathway signaling. Sci Rep 2020; 10: 12528.
14) Tomazic PV, Lang-Loidolt D. Current and emerging pharmacotherapy for pediatric allergic rhinitis. Expert Opin Pharmacother 2021; 22: 849-855.
15) Schuler Iv CF, Montejo JM. Allergic rhinitis in children and adolescents. Immunol Allergy Clin North Am 2021; 41: 613-625.
16) Campo P, Eguiluz-Gracia I, Bogas G, Salas M, Plaza Serón C, Pérez N, Mayorga C, Torres MJ, Shamji MH, Rondon C. Local allergic rhinitis: Implications for management. Clin Exp Allergy 2019; 49: 6-16.
17) Beken B, Eguiluz-Gracia I, Yazıcıoğlu M, Campo P. Local allergic rhinitis: a pediatric perspective. Turk J Pediatr 2020; 62: 701-710.
18) Green RJ, Van Niekerk A, McDonald M, Friedman R, Feldman C, Richards G, Mustafa F. Acute allergic rhinitis. S Afr Fam Pract 2020; 62: e1-e6.
19) Okubo K, Kurono Y, Ichimura K, Enomoto T, Okamoto Y, Kawauchi H, Suzaki H, Fujieda S, Masuyama K. Japanese guidelines for allergic rhinitis 2020. Allergol Int 2020; 69: 331-345.
20) Klimek L, Sperl A, Becker S, M?sges R, Tomazic PV. Current therapeutical strategies for allergic rhinitis. Expert Opin Pharmacother 2019; 20: 83-89.
21) Tham EH, Loo E, Zhu Y, Shek LP. Effects of migration on allergic diseases. Int Arch Allergy Immunol 2019; 178: 128-140.
22) Kim J, Lee E, Lee K, Kim K. Relationships between secondhand smoke incursion and wheeze, rhinitis, and eczema symptoms in children living in homes without smokers in multi-unit housing. Nicotine Tob Res 2019; 21: 424-429.
23) Kef K, Güven S. The prevalence of allergic rhinitis and associated risk factors among university students in anatolia. J Asthma Allergy 2020; 13: 589-597.