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Original article

ENVIRONMENTAL ALLERGEN EXPOSURE IN PATIENTS WITH ALLERGIC RHINITIS IN ZHANGJIAGANG: FINDINGS FROM A SKIN PRICK TEST STUDY

CHEN CHEN, LI MENGLIN, LIU JIANYONG, MA XINGKAI, WU GEPING

Department of Otolaryngology, Zhangjiagang Hospital affiliated to Soochow University, The First People's Hospital of Zhangjiagang City, Zhangjiagang, China

Postal address Li Menglin, Department of Otolaryngology, Zhangjiagang Hospital affiliated to Soochow University,The First People's Hospital of Zhangjiagang City, Zhangjiagang 215600, China
E-mail: zjglmlys@163.com
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Abstract

Introduction: This study aimed to identify the main allergens causing allergic rhinitis (AR) in Zhangjiagang and analyze their epidemiological features.

Materials and methods: From July 2018 to June 2019, 1684 patients with suspected allergic rhinitis in the outpatient department of the First People's Hospital of Zhangjiagang City were tested with an allergen skin prick test (SPT) and statistically analyzed.

Results: The overall SPT positive rate was 65.3%. House dust mites (56.2%) and dust mites (56.0%) were the predominant inhalant allergens. Inhalant allergen positivity (59.4%) significantly exceeded ingested allergens (3.4%). The positive rate of inhalation allergens was significantly higher than that of ingestion allergens (χ^2=1224.83, p<0.05). There was no significant difference in SPT positive rate between males and females (χ2=1.342, p>0.05). Positivity rates declined with age. Seasonally, autumn showed the highest positivity (74.0%), followed by winter (69.3%), summer (64.6%), and spring (54.7%). Specific allergens like birch, willow, rapeseed, Chinese parasol, and ragweed peaked in autumn, while *Alternaria alternata* peaked in summer, and cockroach was higher in autumn/winter.

Conslusion: House dust mites (56.2%) and dust mites (56.0%) are the predominant allergens triggering allergic rhinitis in Zhangjiagang's humid subtropical climate, with inhalant allergens (59.4%) significantly exceeding ingested allergens (3.4%). The distinct age-related decline in allergen positivity, higher cockroach sensitization in males compared to females, and seasonal variation with peak positivity in autumn (74.0%) collectively inform tailored prevention strategies and region-specific immunotherapy protocols for allergic rhinitis management in this region.

Key words: allergic rhinitis, epidemiology, skin prick test, allergen, immunotherapy protocols

Resumen

Exposición a alérgenos ambientales y rinitis alérgica en Zhangjiagang: un estudio de prueba cutánea de punción

Introducción: Este estudio tuvo como objetivo identificar los principales alérgenos de la rinitis alérgica (RA) en Zhangjiagang y analizar sus características epidemiológicas.

Materiales y métodos: Entre julio de 2018 y junio de 2019, 1684 pacientes con sospecha de rinitis alérgica en el departamento de consultas externas del Primer Hospital Popular de la ciudad de Zhangjiagang, fueron

testeados con una prueba cutánea de punción (PCP) y analizados estadísticamente.

Resultados: La tasa global de positividad de la PCP fue del 65.3%. Los ácaros del polvo doméstico (56.2%) y los ácaros del polvo (56.0%) fueron los alérgenos predominantes. La positividad de alérgenos inhalatorios (59.4%) fue significativamente mayor que la de alérgenos ingeridos (3.4%). No se hallaron diferencias significativas por sexo en la positividad global. Las tasas de positividad disminuyeron con la edad. Estacionalmente, el otoño mostró la mayor positividad (74.0%), seguido del invierno (69.3%), verano (64.6%) y primavera (54.7%). Alérgenos específicos como abedul, sauce, colza, parasol china y ambrosía alcanzaron su máximo en otoño, mientras Alternaria alternata lo hizo en verano, y las cucarachas fueron más prevalentes en otoño/invierno.

Conclusión: Los ácaros del polvo doméstico (56.2%) y los ácaros del polvo (56.0%) son los principales alérgenos que desencadenan la rinitis alérgica en el clima subtropical húmedo de Zhangjiagang, con alérgenos inhalatorios (59.4%) significativamente superiores a los alérgenos ingeridos (3.4%). La disminución de la positividad relacionada con la edad, la mayor sensibilización a cucarachas en hombres en comparación con mujeres, y la variación estacional con pico de positividad en otoño (74.0%) orientan estrategias de prevención y protocolos de inmunoterapia específicos para el manejo de la rinitis alérgica en esta región.

Palabras clave: rinitis alérgica, epidemiología, prueba cutánea, alérgenos, protocolos de inmunoterapia

KEY POINTS
Current knowledge

- Allergic rhinitis affects 10-40% of the global population, with regional variations in allergen profiles due to geographical, climatic, and environmental factors. Dust mites typically dominate in humid climates while pollen is more prevalent in temperate regions.

Article's contribution to current knowledge

- In Zhangjiagang's humid subtropical climate, house dust mites and dust mites are predominant allergens. Inhalant allergens significantly exceed ingested, with autumn showing highest positivity. Allergen positivity decreases with age, and males show higher cockroach sensitization than females.

Allergic rhinitis (AR) is a non-infectious inflammatory disease of the nasal mucosa in which specific IgE-mediated release of mediators (mainly histamine), accompanied by a variety of immunoreactive factors and cells, are involved in the response of atopic individuals after exposure to specific sensitizers[1,2]. AR is categorized into seasonal allergic rhinitis (SAR) and perennial allergic rhinitis (PAR), which affects about 10% to 40% of the global population[3]. Of these, SAR is the main type of morbidity and is usually triggered by herbs, tree pollens, etc. In addition to IgE-mediated inflammation, SAR also results from an immune response mediated by type 2 innate lymphocytes (ILC2s) and type 2 helper T cells (Th2), which induce and sustain SAR by releasing cytosolic inflammatory factors, driving immune cells, facilitating protein switching, and activating signaling pathways that attract inflammatory cells and interfere with the intact nasal mucosal barrier[4]. PAR is more likely to be caused by dust mites, animal dander and mold spores, which are present indoors and throughout the year. SAR and PAR do not occur in isolation, and up to 80% of patients have a mixed form of both types[5]. From a clinical point of view, AR is characterized by nasal congestion, episodes of sneezing, profuse watery runny nose and nasal itching, with complications such as bronchial asthma, secretory otitis media and sleep-disordered breathing syndrome in more severe cases[6]. These changes usually arise after exposure to allergens and can be exacerbated during certain seasons. Allergens induce the production of allergen-specific IgE by B-cells in the blood, as well as the activation of nasal mucosal mast cells, which triggers the release of histamine, leading to the development of AR symptoms in the body. Further, eosinophil recruitment also induces additional allergic symptoms and pathologic changes in the nasal mucosa[7].

AR itself is not a malignant disease that is fatal enough, however, it greatly affects the physical and mental health and quality of life of patients, it is also a factor that induces or aggravates a variety of diseases, which brings unnecessary distress and economic burden to patients. Therefore, the study of AR prevention and treatment has been the focus of research in the field of otolaryngology. Currently, the main

methods of AR treatment are allergen avoidance, medication, immunotherapy, and patient education, etc. The most commonly used medications include oral, intranasal or ocular antihistamines, intranasal corticosteroids or a fixed combination of both intranasal antihistamines and corticosteroids[8]. However, the most direct and effective method of AR control would remain allergen avoidance. Both specific immunotherapy and allergen avoidance require predetermination of the allergen type. Understanding the major allergen types in AR and developing a corresponding allergen type spectrum is of great value in the prevention and treatment of AR.

The diagnosis and treatment of AR and its prevention have become major clinical concerns and difficulties. Considering that China is a vast country with large latitude and longitude and that there are significant differences in geographic location, climate, lifestyles, and vegetation cover among provinces, cities, and autonomous regions, the types of allergens inducing AR in different regions may also differ significantly. Targeted regional studies are of greater practical significance for clinical prevention and treatment. At present, relevant studies have been conducted in the western and northern regions of China, but not in the southern region. As a southern city, Zhangjiagang has its unique geography and climate as well as human habits. Zhangjiagang's subtropical climate and industrial growth produce specific allergen exposure situations that necessitate localized evaluations. Clarifying the distribution of the allergen profile in Zhangjiagang City can provide a clinical reference for the prevention of AR and the formulation of medical policies in the region. Thus the objective of this study was to describe the main allergens of allergic rhinitis in the Zhangjiagang area and analyze its epidemiological characteristics, providing a reliable basis for the prevention and treatment of allergic rhinitis.

Materials and methods

This study was approved (approval no. 12/09-FP9) by the Ethical Committee of First People's Hospital of Zhangjiagang City, China. As this was a retrospective analysis of existing clinical data collected during routine patient care, ethics committee specifically waived the requirement for informed consent. All patient data were fully anonymized prior to analysis, with personal identifiers such as names, medical record numbers, and contact information removed to ensure patient confidentiality. The study complied with the Declaration of Helsinki regarding ethical principles for medical research involving human subjects.

Study design and participants

This analytical cross-sectional study retrospectively enrolled 1684 patients presenting with respiratory symptoms consistent with rhinitis in the otolaryngology outpatient department. These patients were admitted to the First People's Hospital of Zhangjiagang City from July 2018 to June 2019 and subsequently underwent skin prick testing.

Exclusion criteria included: 1. Patients with acute attack of asthma. 2. Patients who have taken oral histamines or systemic glucocorticoid drugs within one week. 3. Patients with generalized dermatitis or forearm skin damage. 4. Patients with severe skin scratches. 5. Patients with a history of severe systemic allergy within two weeks. 6. Patients with severe trauma, severe pain, high fever, after major surgery, etc. 7. Patients with prior anaphylactic shock or severe allergic reaction. 8. Pregnant women and patients who refuse skin prick tests.

Research methods

(1) ALK-Abelló standardized skin prick solution was used for the operation and 14 species of allergens were included according to the characteristics of the Zhangjiagang area. Among them, there were 12 allergens in the inhalation group: house dust mites, dust mites, sycamore, ragweed, birch, willow, *Alternaria alternata, Aspergillus niger*, *Aspergillus fumigatus,* canola, dog hair, cockroach. Two allergens in the ingestion group: milk, sea shrimp. The kit should be stored in the refrigerator at 2-8 . Normal saline and histamine were used as negative and positive controls.

(2) The volar aspect of the forearm was selected for testing. Using 70% alcohol to disinfect, dry the area and apply puncture fluid to the skin in a sequence, with more than 2 cm between each two-puncture points. The puncture needle was inserted perpendicularly through the drop of test solution to gently prick the skin, taking care to avoid bleeding. If there is no adverse reaction, the puncture fluid was removed with sterile gauze after 20 minutes, and results are recorded according to the judgment criteria.

(3) Interpretation criteria: The skin reaction was measured 15-20 minutes after application by comparing the

wheal diameter to the positive histamine control (10 mg/mL). The grading system was as follows: (-): no reaction or reaction smaller than negative control; (+): 25-50% of the positive control wheal diameter; (++): 51-100% of the positive control wheal diameter; (+++): 101-200% of the positive control wheal diameter; (++++): greater than 200% of the positive control wheal diameter. SPT results were considered positive when skin reactivity to allergens was graded as + or higher (≥ +).

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(4) Eligible patients underwent standardized skin prick testing using 14 allergen extracts (12 inhalant and 2 ingested allergens) according to ALK-Abelló protocol. Data analysis included primary assessment of overall allergen positivity rates and secondary analyses stratified by sex, age groups (<18 years, 18-44 years, 45-59 years, and ≥60 years), and seasons (spring: March-May, summer: June-August, autumn: September-November, winter: December-February).

Statistical processing

The SPSS 20.0 software package was used for statistical analysis. The chi-square test was used for the comparison of rates, and $p<0.05$ was considered statistically significant.

Results

Participant characteristics

A total of 1684 consecutive patients presenting with clinically suspected allergic rhinitis were evaluated. The cohort comprised 912 males (54.2%). The mean age of all patients was 25.8 ± 0.4 years. Participants underwent skin prick testing according to the study protocol.

Allergen distribution

Among 1684 patients suspected to be AR, 1100 patients were positive for SPT, with a positive rate of 65.3%, and no adverse effects were reported in all patients. We analyzed the results of all positive cases and found that the top five inhalant allergens were house dust mites (56.2%), dust mites (56.0%), rape (11.2%), willow (9.7%), cockroach (9.3%); and the ingestive allergens were sea shrimp (2.6%) and milk (1.1%). Details of the distribution are shown in Table 1, which reveals that house dust mites and dust mites impart considerably to allergen positivity, in alignment with humid climate patterns.

Comparison of positive rate of inhalation and ingestion allergens

Statistical results showed that 1001 cases (59.4%) were positive for one or more inhalation allergens and 58 cases (3.4%) were positive for ingestion allergens. The positive rate of inhaled allergens was higher than that of ingested (χ^2=1224.83, p= 0.00) (Fig. 1).

Comparison of positive rate of different sex allergens

In 1684 patients, 912 cases were male, with a positive rate of 66.6%; 772 cases were female. There was no statistically significant difference in overall allergen positivity between genders (χ^2 = 1.342, p = 0.246) (Fig. 2).

Description of results among females and males are described in Table 2. This indicates that the major inhalant allergens were similar between genders, with slight differences in positive rates. Whereas in sycamore, ragweed, birch, willow and cockroach, the gender difference was statistically significant ($p<0.05$).

Comparison of positive rate of allergens at different ages

Description of results among age groups are described in Table 3. There was a statistically significant difference in the total positivity rate between different age groups ($p<0.05$), with the rate decreasing with age. Statistically significant differences were also found in the positivity rates of house dust mites, dust mites, ragweed, Alternaria alternata, *Aspergillus niger* and cockroaches at different ages.

Tabla 1 | Distribution of various allergens*

Allergen	+	++	+++	++++	Total positive	Positive rate (%)
House dust mites	60	97	223	566	946	56.2
Dust mites	64	121	279	479	943	56.0
Chinese parasol tree	33	11	20	10	74	4.4
Ragweed	37	5	1	0	43	2.6
Birch	33	4	14	3	54	3.2
Willow	90	18	5	49	162	9.6
Alternaria alternata	33	21	1	19	74	4.4
Aspergillus niger	4	3	1	0	8	0.5
Aspergillus fumigatus	7	2	2	0	11	0.7
Rapeseed	99	62	25	3	189	11.2
Dog hair	17	8	2	1	28	1.7
Cockroach	88	14	45	10	157	9.3
Milk	11	2	4	1	18	1.1
Sea shrimp	20	6	17	0	43	2.6

** Skin prick testing (SPT) positive results*

Figure 1 | Comparison of positive rate of inhaled and ingested allergens

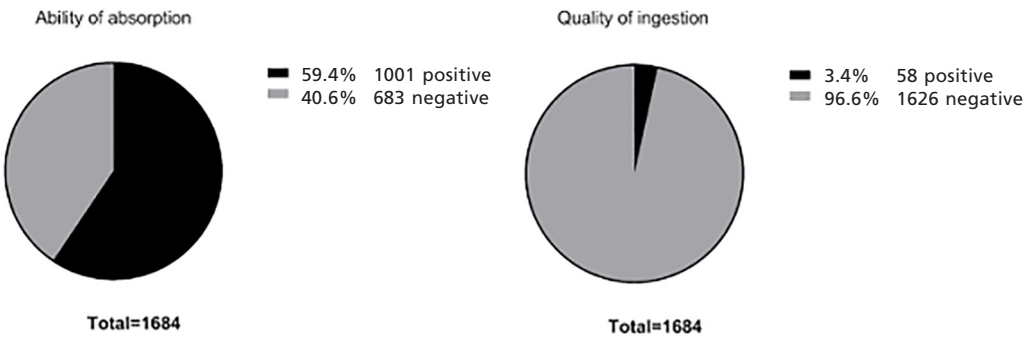

Figure 2 | Comparison of positive rate of allergens in different genders

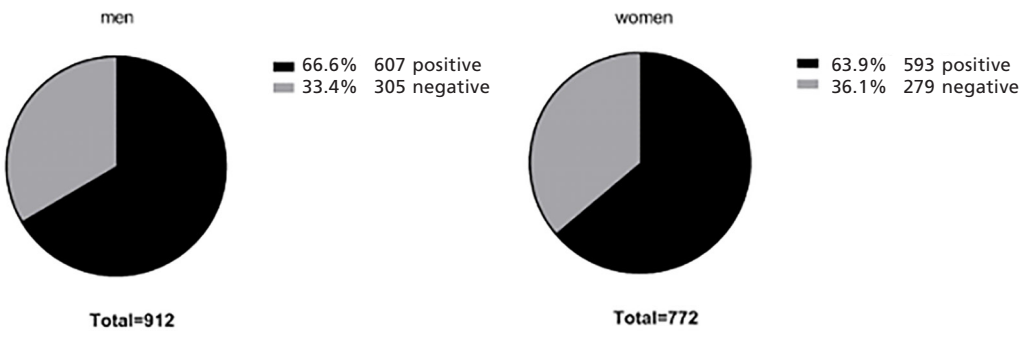

Tabla 2 | Allergen-specific positivity by gender (%)

Allergen	Male (%)	Female (%)	χ^2	p-value
House dust mites	55.7	56.7	0.182	0.67
Dust mites	55.5	56.6	0.214	0.64
Chinese parasol tree	5.7	2.9	8.095	0.00
Ragweed	3.4	1.6	5.718	0.02
Birch	4.4	1.8	8.914	0.00
Willow	12.2	6.6	14.891	0.00
Alternaria alternata	4.8	3.9	0.877	0.35
Aspergillus niger	0.3	0.7	0.898	0.34
Aspergillus fumigatus	0.7	0.7	0.001	0.98
rapeseed	12.6	9.6	3.838	0.05
Dog hair	1.9	1.4	0.493	0.48
Cockroach	11.2	7.3	7.219	0.01
Milk	1.0	1.2	0.127	0.72
Sea shrimp	2.6	2.5	0.049	0.83

Tabla 3 | Allergen positivity by age group (%)

Allergen	<18 years (n=686)	18-44 years (n=702)	45-59 years (n=244)	60 years (n=52)	χ^2	p-value
Overall positivity	77.0	61.8	48.4	38.5	92.415	0.00
House dust mites	70.0	52.4	36.5	17.3	114.517	0.00
dust mites	70.0	52.7	34.0	19.2	133.819	0.00
Chinese parasol tree	4.7	4.1	4.1	5.8	0.520	0.91
Ragweed	1.3	3.1	4.5	1.9	9.030	0.03
Birch	2.9	4.0	1.6	3.9	3.570	0.31
Willow	8.2	10.7	10.3	11.5	2.918	0.40
Alternaria alternata	8.9	1.4	1.2	0.0	55.978	0.00
Aspergillus niger	0.4	0.4	0.0	3.9	13.718	0.00
Aspergillus fumigatus	0.9	0.1	1.2	1.9	5.881	0.11
rapeseed	9.5	13.1	10.3	13.5	5.095	0.17
Dog hair	1.5	1.4	2.9	1.9	2.612	0.46
Cockroach	5.0	13.0	11.5	7.7	27.976	0.00
Milk	0.9	1.4	0.4	1.9	2.445	0.49
Sea shrimp	2.3	2.9	2.5	1.9	0.473	0.93

Comparison of positive rate of allergens in different seasons

We divided the year into spring (March to May), summer (June to August), fall (September to November), and winter (December to February). It was found that the highest number of patients with AR visited the hospital and underwent skin prick tests in summer (34.0%) and the lowest in winter (10.5%) during the year. The season with the highest allergen positivity rate was autumn (74.0%). House dust mites and dust mites had the highest percentage in all four seasons. Birch, willow, Chinese parasol tree, and ragweed accounted for significantly higher percentages in fall than in other seasons. *Alternaria alternata* showed the highest prevalence in

summer, and cockroaches showed higher rates in fall and winter than in spring and summer. Other inhalant allergens: *Aspergillus niger, Aspergillus fumigatus*, dog hair and ingestible allergens milk and sea shrimp did not show statistically significant differences in seasonal variation. Table 4 presents the detailed data.

Discussion

Clinical symptoms of AR include paroxysmal sneezing, runny nose, nasal congestion, and nasal itching, which may also be accompanied by pharyngeal itching, eye itching, conjunctival congestion, and other related organ symptoms, thus seriously affecting the patients' learning, work, sleep, facial development, vocal function, and even the quality of life, causing a huge mental and economic burden to the patients and their families[9,10]. Therefore, the prevention and treatment of AR have become the focus and difficulty of clinical work[11]. With the rapid development of the current economy, increasingly serious air pollution and changes in people's diet and lifestyle, the number of patients with AR is increasing year by year. According to statistics, about 600 million people worldwide suffer from AR and the prevalence trend is increasing. AR has become a global health problem[12,13]. However, so far, there is no effective method to curb the continuously increasing trend of AR prevalence both domestically and internationally[14].

At present, the treatment of AR mainly involves four aspects: allergen avoidance, drug therapy, specific immunotherapy and patient education. Epidemiologic studies can enhance social awareness of the sources of AR[15,16], which is of great significance in AR prevention, diagnosis and treatment[17]. Therefore, it is very important to clarify the distribution of the allergen spectrum in this area, which can provide a reliable basis for AR pretreatment[18].

The climate, economic conditions and lifestyles vary from country to country or region to region, which means that allergen profiles and allergenic factors will not be completely the same. Even in urban and rural areas of the very

Tabla 4 | Seasonal variation in allergen positivity (%)

Allergen	Spring (n=435)	Summer (n=573)	Autumn (n=500)	Winter (n=176)	χ^2	p-value
Overall positivity	54.7	64.6	74.0	69.3	39.62	0.00
House dust mites	44.8	56.9	63.4	61.4	35.399	0.00
dust mites	41.2	53.9	62.0	62.5	19.497	0.00
Chinese parasol tree	2.8	3.7	6.4	5.1	8.500	0.04
Ragweed	0.2	2.27	5.6	0.6	31.064	0.00
Birch	1.6	2.6	5.0	2.3	10.273	0.02
Willow	3.9	8.7	16.2	8.0	42.310	0.00
Alternaria alternata	1.4	7.0	3.6	5.7	19.982	0.00
Aspergillus niger	0.2	0.7	0.2	1.1	3.584	0.31
Aspergillus fumigatus	0.2	1.05	0.2	1.7	7.152	0.67
rapeseed	6.0	11.5	16.6	8.0	28.461	0.00
Dog hair	1.4	1.6	2.2	1.1	1.424	0.70
Cockroach	2.1	8.6	15.4	12.5	51.423	0.00
Milk	0.5	1.6	1.0	1.1	2.921	0.40
Sea shrimp	1.4	2.8	3.8	1.1	7.084	0.07

**Note: Dust mites positivity in Spring (41.2%) was significantly lower than in other seasons (Summer: 53.9%, Autumn: 62.0%, Winter: 62.5%). This pattern aligns with Zhangjiagang's subtropical monsoon climate where spring (March-May) typically has lower humidity levels compared to other seasons, creating less favorable conditions for dust mite proliferation. After verifying the data collection procedures and laboratory protocols for consistency across all seasons, we confirmed the accuracy of this finding. This seasonal variation is consistent with previous studies in southern China that report lower dust mite sensitization during drier spring months (Xu et al., 2021; Wang et al., 2022).*

same region, allergen profiles and allergenic factors may be characterized in their way[19,20]. Zhangjiagang is located in the east of mainland China, on the south bank of the lower reaches of the Yangtze River. It is a county-level city under the jurisdiction of Suzhou. The whole territory of Zhangjiagang is flat and belongs to the humid climate zone in the south of the North subtropical zone, with four distinct seasons, mild climate and abundant rain[21].

Currently, the main tests for AR allergen profile consist of the skin prick test (SPT) and serum allergen-specific IgE detection, of which SPT is the fastest, safe, sensitive, simple and cost-effective method[22,23]. In a prospective study of 6000 children, the incidence of systemic adverse reactions by skin prick test was only 0.001%[24], so it can be widely used in clinics. Before SPT is performed, the skin needs to be cleaned with 70% ethanol solution, while the locations of punctures should be at least 2cm apart to avoid overlapping reactions[25,26]. Both negative and positive controls should be established.

Our finding of house dust mites and dust mites as predominant allergens aligns with studies from other subtropical regions in southern China[27,28], but contrasts with northern Chinese cities like Beijing where pollen allergens predominate[22]. This regional variation likely reflects Zhang jia gang's humid subtropical climate (annual rainfall >1100mm), which creates ideal conditions for dust mite proliferation compared to drier northern regions. The high prevalence (56.2% and 56.0%) suggests that immunotherapy protocols in this region should prioritize dust mite allergens, consistent with ARIA 2020 guidelines, which recommend region-specific allergen selection for immunotherapy. Zhangjiagang belongs to the subtropical monsoon climate, the annual rainfall is large, humid and warm, and the economy is developed, air pollution is considered severe, coupled with a high rate of air conditioning usage, which provides favorable conditions for the growth of dust mites. Xu et al.[27] found that the most common combination of double allergens was house dust mites + dust mite (61%), which was consistent with the results of our study. Domestic studies have confirmed that the distribution of dust mites in southern and central areas of China is significantly higher than that in northern areas[29,30]. At present, effective measures to avoid dust mites include physical barriers, humidity control and reducing the areas where dust mites can live. Other measures to reduce exposure to dust mites' allergens include heat treatment, acaricides and allergenic denaturants.

While overall SPT positivity showed no gender difference (66.6% vs 63.9%, p=0.25), our finding of higher cockroach sensitization in males (11.1% vs 7.3%, p=0.01) contrasts with Shanghai's study where females showed greater cockroach sensitivity[31]. This may reflect Zhangjiagang's unique urbanization patterns and water-rich environment that disproportionately exposes males to cockroach habitats. Clinically, this suggests gender-specific environmental assessments may be warranted during patient evaluations, particularly for male patients presenting with autumn/winter-predominant symptoms. Cockroaches are more common in the allergen spectrum in the Zhangjiagang area, and occur more frequently in autumn and winter, among which, they are more common in male patients, which may be related to the abundant water area in Zhangjiagang and the rapid urbanization development. Therefore, we believe that patients need to be asked at the time of the visit if they have seen cockroaches in their houses, but cockroaches may exist even if they have not. A 2013 code of practice recommends that integrated pest management can be used to eliminate and prevent cockroach infestations, including the removal of cockroach detritus, cleaning of infestation areas, setting of multiple bait traps and poisons, and the removal of factors contributing to infestation (such as standing water or access to garbage or unwashed cutlery)[32].

The age-related decline in allergen positivity (70.0% in <18 years to 38.5% in ≥60 years) mirrors global patterns observed in Japan and European cohorts, suggesting a universal 'immunosenescence' phenomenon in allergic responses. However, unlike Western populations where pollen sensitization increases with age, our data show persistent dust mite dominance across all age groups in Zhangjiagang. This has significant implications for immunotherapy duration—pediatric patients may benefit from longer treatment courses due to higher initial sensitization, while

elderly patients might require modified protocols focusing on fewer allergens. Our finding of elevated *Alternaria alternata* in children (8.9% vs 1.4% in adults) warrants special attention, as early fungal sensitization has been linked to asthma progression[31,33].

Seasonally, the number of AR patients with skin prick tests was the most in summer and autumn, and the least in winter. In the four seasons, the positive rate of allergens from high to low was autumn, winter, summer and spring. Among them, birch, willow, rapeseed, Chinese parasol and ragweed are significantly higher in autumn than in other seasons. The reason for this may be speculated to be that hot weather and high usage of air conditioners in summer and fall in Zhangjiagang are conducive to the growth of dust mites, thus increasing the incidence of AR.

The autumn peak in allergen positivity (74.0%) contrasts with northern Chinese cities like Beijing where spring pollen season dominates, reflecting Zhangjiagang's distinct subtropical vegetation cycle. Our finding of significantly higher birch, willow, and ragweed sensitization in autumn (vs spring/summer) aligns with southern China's unique 'second pollen season' phenomenon, likely due to the region's diverse flora including late-blooming species. This has practical implications for allergen avoidance strategies: unlike temperate regions where spring is the critical period, Zhangjiagang patients require intensified preventive measures from September through November. Furthermore, the summer peak in *Alternaria alternata* (7.0%) exceeds levels reported in most Chinese studies, suggesting that fungal immunotherapy should be incorporated into summer treatment protocols, particularly for pediatric patients. Zhangjiagang area has a lot of green vegetation, so autumn is also the pollen allergy season in Zhangjiagang area. During these seasons, we recommend avoiding exposure to allergens whenever possible. Possible measures include closing windows and doors when in your home and car, staying indoors more often, or using air conditioning filtration. After presenting outdoor exposure, rinse nasal passages with physiologic seawater to remove allergens from the inner surface of the nose. Showering before bed to get rid of allergens from hair and skin as well as to minimize contamination of bedding. We also found that in the Zhangjiagang area, the occurrence of *Alternaria alternata* was higher in summer than in other seasons. As a dark fungus widely distributed in nature and a common saprophyte on soil, plants, food and industrial materials, the optimum temperature for its growth is 20 ~ 30°, and the optimum temperature is 28°. Higher incidence in summer may be related to the hot weather[34].

This study has several methodological limitations that warrant consideration. First, our exclusion criteria included patients with acute asthma attacks, generalized dermatitis, or severe systemic allergies within two weeks, which may have introduced selection bias by excluding patients with more severe allergic conditions. This could potentially underestimate the prevalence of certain allergens that might be more common in severe cases. Second, the inclusion criteria focused on patients with respiratory symptoms consistent with rhinitis, but these symptoms could also be caused by upper respiratory tract infections or other non-allergic conditions, which might have led to misclassification bias. Although we relied on clinical diagnosis by experienced otolaryngologists and subsequent skin prick testing to confirm allergic etiology, some non-allergic rhinitis cases might have been inadvertently included. Third, as a single-center study conducted in an otolaryngology department, our sample may not fully represent the general population with allergic rhinitis in Zhangjiagang, as patients seeking specialist care might have more severe or persistent symptoms compared to those managed in primary care settings. Fourth, our non-probabilistic sampling approach, while practical for clinical settings, limits the generalizability of findings to the broader population.

Our findings differ significantly from those reported in Latin American studies. In Brazil, for instance, a multi-center study by Sole et al. (2019) found that pollen allergens (particularly grasses and weeds) dominated the allergen profile (68.3%), with dust mites accounting for only 27.5% of positive reactions. This contrasts sharply with our findings where dust mites constituted over 56% of positive reactions. Similar-

ly, a Colombian study by Sánchez-Borges et al. (2020) reported that ragweed and grass pollens were the primary sensitizers (42.7% and 38.5% respectively), while dust mites represented only 31.2% of positive tests. These differences likely reflect the distinct climatic conditions: Latin American regions with more seasonal variation and lower humidity show higher pollen sensitization, while Zhangjiagang's humid subtropical climate favors dust mite proliferation. This regional variation underscores the importance of localized allergen profiling for effective clinical management.

Future multi-center studies with broader inclusion criteria, differential diagnosis protocols to distinguish allergic from non-allergic rhinitis, and probabilistic sampling methods could provide more comprehensive insights into the allergen profile of the region. Additionally, longitudinal studies tracking seasonal variations over multiple years would help confirm the observed autumn peak in allergen positivity.

In conclusion, epidemiological analysis of the allergen profile of AR patients in Zhangjiagang is conducive to the standardized management of various risk factors at an early stage. At the same time, it effectively guides patients to avoid contact with relevant allergens and take appropriate treatments to effectively manage patients and prevent the development of AR. Identifying allergens can also provide a direction for clinical treatment in the region, thus improving the quality of life of patients with AR.

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