

Application of Subcutaneous Immunotherapy in Pediatric Patients with Allergic Rhinitis and Analysis of Logistic Regression Models

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ABSTRACT

This study aimed to investigate the clinical efficacy of subcutaneous immunotherapy (SCIT) in pediatric patients with allergic rhinitis (AR) and to analyze influencing factors associated with treatment outcomes.

A total of 153 pediatric AR patients receiving SCIT were retrospectively enrolled. Patients were categorized into effective and ineffective groups according to treatment response. Clinical characteristics were collected and compared between groups. Differential variables were subjected to multicollinearity analysis and subsequently included in logistic regression analysis to identify risk factors for poor treatment response. A nomogram prediction model was established, and its predictive performance was internally validated using receiver operating characteristic (ROC) analysis.

Following SCIT treatment, 20 patients (13.07%) showed no therapeutic response, while the overall response rate reached 86.93%. Significant differences between groups were observed in sex, family history, place of residence, total immunoglobulin E (IgE), dust mite-specific IgE, and eosinophil count (EOS). Variance inflation factor (VIF) analysis demonstrated no multicollinearity among variables. Logistic regression identified all above indicators as independent risk factors for treatment failure (OR>1). The nomogram model showed excellent predictive performance, with an AUC of 0.924 (95% CI, 0.856–0.991).

SCIT demonstrated favorable clinical efficacy in pediatric AR patients. Gender, family history, place of residence, total IgE, dust mite sIgE, and EOS were independent predictors of poor treatment outcomes and may facilitate early identification of high-risk populations.

Keywords: Allergic rhinitis; Influencing factors; Prediction model; Subcutaneous immunotherapy

INTRODUCTION

Allergic rhinitis (AR), or “hay fever”, describes

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an IgE-mediated inflammatory reaction of the nasal mucosa. It occurs in susceptible people after allergen exposure, with the participation of multiple immune cells and cytokines. As a widespread chronic respiratory disorder worldwide, AR imposes a heavy disease burden and greatly impairs patients' daily life, rendering it an important public health issue.¹⁻³ Zeng X and colleagues⁴ reported that typical AR manifestations include nasal pruritus, paroxysmal sneezing, rhinorrhoea and nasal

congestion, and the spectrum and severity of symptoms differ across patient subgroups. Apart from local discomfort, AR can be complicated by other airway conditions such as bronchial asthma, which further raises healthcare expenditure and economic costs, and substantially worsens patients' physical well-being and life quality. Hence, safe and evidence-based interventions are essential for affected individuals.

Fan K et al.⁵ proposed that the management framework for allergic rhinitis consists of four pillars: allergen avoidance, pharmacotherapy, allergen-specific immunotherapy (AIT), and patient education. Among these strategies, AIT is the only intervention that may modify the natural history of allergic disorders via immunoregulatory pathways and has attracted growing research interest. By stepwise escalation of allergen doses, AIT induces clinical and immune tolerance, lowers symptom reactivity upon subsequent allergen exposure, improves long-term quality of life, and halts disease progression.⁶ Subcutaneous immunotherapy (SCIT) represents the major modality of AIT, with a history spanning over a century since its first use in 1911. This strategy delivers incremental low-dose allergens through subcutaneous injections to build immune tolerance and decrease allergen hypersensitivity.⁷⁻⁹ Cumulative clinical evidence confirms the sustained therapeutic benefits of SCIT. It markedly reduces patients' reliance on symptomatic drugs, and the therapeutic effect persists even after treatment discontinuation. Supported by abundant clinical data, SCIT shows promising prospects for managing allergic rhinitis. However, clinical practice shows that SCIT does not yield favorable responses in all patients with allergic rhinitis (AR). A proportion of individuals exhibit insufficient therapeutic effects or develop adverse events during treatment, resulting in unsatisfactory clinical outcomes.^{10,11} Accordingly, identifying the determinants that modulate SCIT efficacy among AR patients is vital to refine clinical implementation and improve therapeutic performance. Logistic regression represents a commonly adopted statistical approach for evaluating and predicting disease-related risk factors. It enables researchers to explore variables linked to disease occurrence and prognosis, thereby offering evidence to support the formulation of targeted preventive strategies and therapeutic regimens. Against this backdrop, the present study seeks to evaluate the clinical efficacy of SCIT in AR patients, verify its therapeutic value and safety profile, and supply

more credible evidence for clinical practice. Furthermore, logistic regression modelling is employed to analyze predictors of treatment response, so as to provide a scientific foundation for designing optimal preventive and therapeutic strategies.

MATERIALS AND METHODS

Ethical Statement

This study was approved by the Institutional Review Board and Ethics Committee. Given its retrospective nature and use of de-identified patient data, informed consent was not required as it posed no risk or adverse impact on patient care. This exemption complies with regulations and ethical guidelines pertaining to retrospective research.

Study Design

This retrospective study included 153 patients with AR who underwent SCIT at our hospital between January 2021 and January 2025. General demographic and clinical data were collected from the medical record system.

Inclusion and Exclusion Criteria

Inclusion Criteria: (1) All patients met the AR diagnostic criteria outlined in the Chinese Guidelines for the Diagnosis and Treatment of Allergic Rhinitis¹² and exhibited clinical symptoms such as nasal discharge, nasal congestion, nasal itching, or any of the following nasal mucosal manifestations: pallor or edema; (2) All patients received SCIT treatment; (3) Age <16 years; (4) Complete clinical records.

Exclusion Criteria: (1) Presence of immunodeficiency disorders; (2) Allergic reactions within the past week; (3) Receipt of other vaccinations (e.g., vaccines against viruses or bacteria) within the past week; (4) Concurrent severe cardiac, hepatic, renal, or other organ diseases; (5) Concurrent severe neurological disorders or cognitive impairment.

Treatment Method

All patients received SCIT using Acaroid (house dust mite allergen preparation, approval number: S20140015, ALK-Abello A/S, specification: 5 mL) administered via subcutaneous injection. A 1-mL syringe was used, with the needle inserted at a 45° angle into the patient's skin. Prior to injection, aspiration was performed; injection proceeded only after confirming no blood return, ensuring

completion within 1 minute. The initial treatment phase lasted 15 weeks, 1 injection per session per week. The dosage is gradually increased from 20 SQ-U to 100 000 SQ-U. After 15 weeks, maintenance therapy commences with injections administered once every 6 weeks, 1 injection per session.

Data Collection

The following general demographic and clinical information were recorded and collected for each patient: age; sex (male/female); family history (present/absent), allergy history (present/absent); allergens (single/multiple); place of residence (urban/rural); onset season (spring/summer/autumn/winter); presence of household pets (yes/no); concomitant asthma (yes/no), history of eczema (yes/no); dietary habits (balanced meat/vegetables or unbalanced); and passive smoking exposure (yes/no).

Total Immunoglobulin E (IgE) Testing

Fasting venous blood (2 mL) was collected from patients in the morning. The samples were centrifuged at 3000 rpm for 10 minutes (Model: LL900, Manufacturer: Luoyang Hongshi Machinery Equipment Co., Ltd.) to separate serum. Total IgE levels were determined using a fully automated biochemical analyzer (Model: Beckman AU5800, Country of Origin: USA).

Eosinophil Count (EOS) Testing

Fasting venous blood (2 mL) was collected from patient in the morning. The sample was placed in an EDTA anticoagulant tube, mixed thoroughly, and a smear was prepared using one drop of the sample. After Giemsa staining, the eosinophil percentage was calculated using an oil immersion microscope. Eosinophil counts were also determined using a fully automated hematology analyzer (Model: BC-5000, Manufacturer: Mindray).

Dust Mite sIgE Detection

Serum dust mite sIgE was measured using a sandwich ELISA method. sIgE results were classified into 6 levels according to the UniCAP classification standard: Grade 0: < 0.35 IU/mL; Grade 1: 0.35–0.70 IU/mL; Grade 2: 0.70–3.50 IU/mL; Grade 3: 3.50–17.50 IU/mL; Grade 4: 17.50–50.00 IU/mL; Grade 5: 50.00–100.00 IU/mL; and Grade 6: > 100.00 IU/mL.

Clinical Efficacy

Clinical efficacy was assessed based on the Total Nasal Symptom Score (TNSS)¹³, which includes patient-reported symptoms of rhinorrhea, sneezing, nasal congestion, and nasal itching, with each symptom scored according to the frequency of occurrence; (0=no symptoms, 3= severe symptoms, higher scores indicate more frequent symptom occurrence). The total score is ranges from 0 to 12, and the score is directly proportional to symptom severity). The clinical symptom improvement rate was assessed as: Improvement Rate=(Pre-treatment Total Score – Post-treatment Total Score)÷Pre-treatment Total Score×100%. Improvement rates were classified as follows: > 65%= marked efficacy; 25%–65% = effective; and <25% = ineffective.

Observation Indicators

Data on poor clinical outcomes following SCIT treatment were collected. Clinical records were compared between the effective and ineffective groups. Collinearity analysis was performed for indicators showing differences in univariate analysis. Multivariate analysis was performed on indicators without collinearity issues to identify factors influencing clinical efficacy. A regression model was then constructed and validated based on these findings.

Statistical Analysis

Data were analyzed using SPSS 25.0 statistical software. Count data were expressed as n and analyzed using χ^2 tests. Normally distributed continuous data were represented as mean±SD and analyzed using *t* tests. A *p*<0.05 was considered statistically significant. Multivariate logistic regression analysis was performed on differential indicators to construct a regression model. Receiver operating characteristic (ROC) curves were plotted for internal validation to assess the model's discrimination and calibration.

RESULTS

Clinical Efficacy of SCIT in AR Patients

Following SCIT treatment, 20 out of 153 AR patients (13.07%) showed no therapeutic response and were classified into the non-responsive group. Ninety patients demonstrated marked improvement (58.82%) and 43 showed improvement (28.10%), yielding an overall response rate of 86.93% (133/153).

Univariate Analysis of Factors Affecting SCIT Treatment Outcomes in AR Patients

Significant differences were observed between the two groups in sex, family history, place of residence,

total IgE, dust mite sIgE, and eosinophil count ($\chi^2/t=9.955, 7.246, 8.465, 8.418, 9.422, 7.967$; $p<0.05$), as shown in Table 1.

Table 1. Single factor analysis of SCIT treatment effect in AR patients.

Variable	Non-responsive group (n=20)	Responsive group (n=133)	χ^2/t	<i>p</i>
Age, y	8.75±1.74	8.80±1.69	0.123	0.902
Sex, n	NA	NA	9.955	0.002
Male	15	50	NA	NA
Female	5	83	NA	NA
Family history, n	NA	NA	7.246	0.007
Yes	8	20	NA	NA
No	12	113	NA	NA
Allergy history, n	NA	NA	2.759	0.097
Yes	7	25	NA	NA
No	13	108	NA	NA
Allergen, n	NA	NA	1.110	0.292
Single	8	70	NA	NA
Multiple	12	63	NA	NA
Place of residence, n	NA	NA	8.465	0.004
Urban	16	60	NA	NA
Rural	4	73	NA	NA
Onset season, n	NA	NA	0.047	0.997
Spring	8	50	NA	NA
Summer	3	20	NA	NA
Autumn	6	42	NA	NA
Winter	3	21	NA	NA
No pets in the home, n	NA	NA	3.564	0.059
Yes	6	18	NA	NA
No	14	115	NA	NA
Concomitant asthma, n	NA	NA	1.198	0.274
Yes	15	83	NA	NA
No	5	50	NA	NA
History of eczema, n	NA	NA	2.624	0.105
Yes	11	48	NA	NA
No	9	85	NA	NA
Diet, n	NA	NA	2.550	0.110
Balanced	8	31	NA	NA
Unbalanced	12	102	NA	NA
Passive smoking, n	NA	NA	3.141	0.076
Yes	6	19	NA	NA
No	14	114	NA	NA
Total IgE level, n	NA	NA	8.418	0.004
Grade 6	17	67	NA	NA
<Grade 6	3	66	NA	NA
Dust mite sIgE level, n	NA	NA	9.422	0.002
Grade 6	8	17	NA	NA
<Grade 6	12	116	NA	NA
EOS, ×10 ⁶ /L	558.78±87.34	413.46±74.29	7.967	<0.001

AR: allergic rhinitis; EOS: eosinophil count; IgE: immunoglobulin E; SCIT: subcutaneous immunotherapy; sIgE: specific immunoglobulin E.

Subcutaneous Immunotherapy in Allergic Rhinitis: Logistic Analysis

Variable Assignment Table

Using the efficacy of SCIT treatment for AR patients as the dependent variable and sex, family history, place of residence, total IgE, dust mite sIgE, and eosinophil count (EOS) as independent variables, corresponding assignments were performed for each independent variable, as shown in Table 2.

Collinearity Analysis

Collinearity results revealed that sex, family history, place of residence, total IgE, dust mite-specific IgE, and EOS exhibited no collinearity issues ($VIF \leq 10$,

tolerance ≥ 0.1). These indicators can be incorporated into the logistic regression model, as shown in Table 3.

Logistic Multivariate Analysis of Factors Affecting SCIT Treatment Outcomes in AR Patients

Logistic regression analysis revealed that sex, family history, place of residence, total IgE, dust mite-specific IgE, and eosinophil count (EOS) were all risk factors affecting SCIT treatment efficacy in AR patients (OR=4.980, 3.767, 4.867, 5.582, 4.549, 1.025; 95% CI, 1.706–14.536, 1.368–10.374, 1.545–15.334, 1.562–19.948, 1.625–12.733, 1.015–1.035; $p < 0.05$), as shown in Table 4.

Table 2. Variable assignment table.

Variable	Assignment
Therapeutic effect of SCIT	0 = responsive, 1 = non-responsive
Sex	0 = female, 1 = male
Family history	0 = no, 1 = yes
Place of residence	0 = rural, 1 = urban
Total IgE level	0 = <Grade 6, 1 = Grade 6
Dust mite sIgE level	0 = <Grade 6, 1 = Grade 6
EOS	Measured value

AR: allergic rhinitis; EOS: eosinophil count; IgE: immunoglobulin E; SCIT: subcutaneous immunotherapy; sIgE: specific immunoglobulin E.

Table 3. Collinearity analysis.

Influencing factor	VIF	Tolerance
Therapeutic effect of SCIT	4.433	0.226
Sex	8.246	0.121
Family history	8.289	0.121
Place of residence	5.290	0.189
Total IgE level	7.825	0.128
Dust mite sIgE level	1.050	0.953

EOS: eosinophil count; IgE: immunoglobulin E; SCIT: subcutaneous immunotherapy; sIgE: specific immunoglobulin E; VIF: variance inflation factor.

Table 4. Multivariate logistic analysis of the effect of SCIT in AR patients.

Influencing factor	β	SE	Wald χ^2	<i>p</i>	OR	95% CI
Therapeutic effect of SCIT	1.605	0.547	8.628	0.003	4.980	1.706–14.536
Sex	1.326	0.517	6.583	0.010	3.767	1.368–10.374
Family history	1.582	0.588	7.303	0.007	4.867	1.545–15.334
Place of residence	1.720	0.650	7.003	0.008	5.582	1.562–19.948
Total IgE level	1.515	0.525	8.322	0.004	4.549	1.625–12.733
Dust mite sIgE level	0.025	0.005	26.183	<0.001	1.025	1.015–1.035

AR: allergic rhinitis; CI: confidence interval; EOS: eosinophil count; IgE: immunoglobulin E; OR: odds ratio; SCIT: subcutaneous immunotherapy; SE: standard error; sIgE: specific immunoglobulin E.

Constructing Nomogram Models Based on Logistic Analysis Results

Based on the results of the multivariate logistic regression analysis, six independent factors—sex, family history, place of residence, total IgE, dust mite-specific IgE, and eosinophil count—were selected as predictors. A corresponding nomogram was generated to visually and individually assess the incidence of SCIT treatment failure in patients. The sum of the predicted

point scores for each variable corresponds to the scale at the bottom of the nomogram, as shown in Figure 1.

Internal Validation

Figure 2 presents the ROC curve, with an AUC value of 0.924 (95% CI, 0.856–0.991). This indicates that the predictive model exhibits high overall accuracy and demonstrates strong consistency with actual risk.

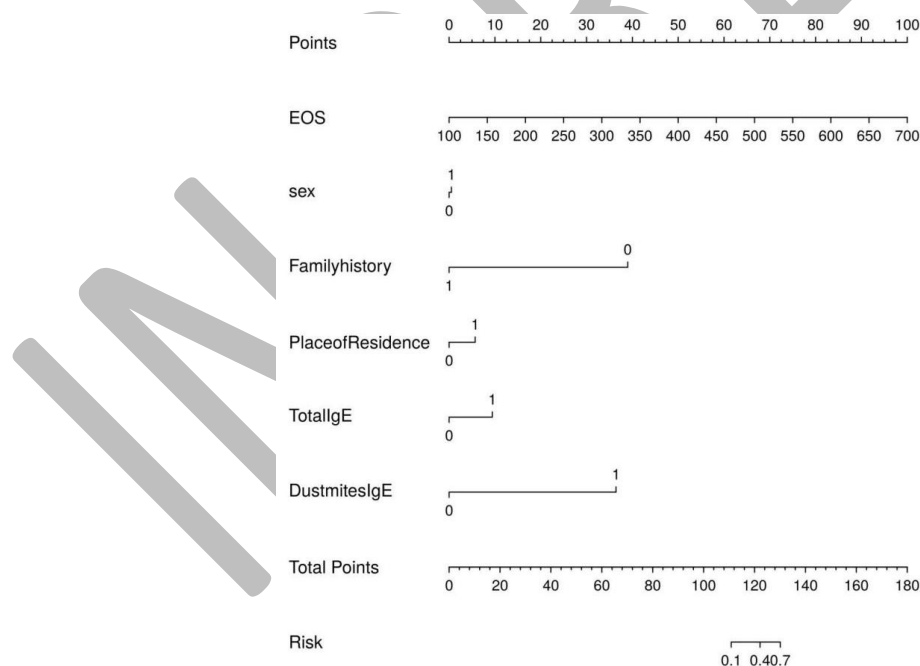


Figure 1. Construction of a nomogram model. The nomogram was established based on the results of multivariate logistic regression analysis and incorporated six independent predictors, including sex, family history, place of residence, total IgE level, dust mite-specific IgE level, and eosinophil count (EOS). Each predictor corresponds to a specific point value on the upper scoring scale. The total score, obtained by summing the points for all variables corresponds to the predicted probability of SCIT treatment failure shown at the bottom of the nomogram. Higher total scores indicate a greater risk of poor therapeutic response to SCIT.

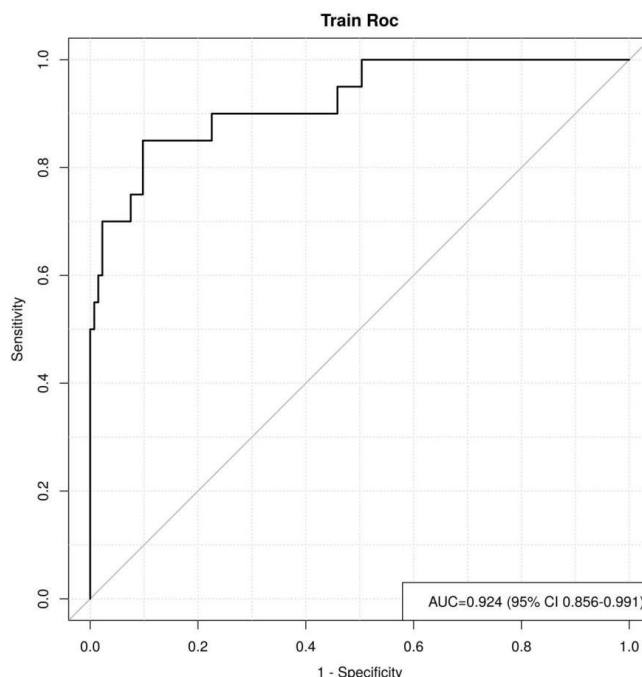


Figure 2. Internal validation ROC curve. The ROC curve was used to evaluate the predictive performance and discrimination ability of the nomogram model for SCIT treatment outcomes in pediatric allergic rhinitis patients. The area under the curve (AUC) was 0.924 (95% CI, 0.856–0.991), indicating excellent predictive accuracy and strong agreement between the predicted risk and actual clinical outcomes. Sensitivity and specificity were assessed across different cutoff values to determine the overall diagnostic performance of the model.

DISCUSSION

Allergic rhinitis (AR) is a common chronic inflammatory disease with a current clinical prevalence of 10% to 25%, showing an upward trend annually and severely impacting patients' health. Subcutaneous immunotherapy (SCIT) is currently an effective clinical treatment for AR patients, but its clinical application is limited due to factors such as high costs.^{14,15} According to relevant literature, SCIT effectively alleviates clinical symptoms with high therapeutic efficacy. Nevertheless, multiple factors negatively impact treatment outcomes in some patients.¹⁶ Therefore, actively analyzing factors influencing SCIT efficacy in AR patients is crucial for improving treatment results. This study found that among 153 AR patients treated with SCIT, 20 (13.07%) showed no therapeutic response, while 90 (58.93%) demonstrated marked improvement and 43 (28.10%) showed improvement. Significant differences were observed between the two groups in terms of sex, family history, place of residence, total IgE, dust mite-specific IgE, and eosinophil count. These factors were all identified as risk factors for treatment failure. This

indicates that SCIT demonstrates good efficacy in the clinical management of AR patients, but treatment failure occurs in some patients due to the influence of multiple factors. The gut serves as a vital immune organ housing extensive microbial community. Gut microbiota not only modulate the intestinal microenvironment and function but also influence the development and progression of various respiratory diseases through mucosal immunity and metabolic regulation. Serine palmitoyltransferase produced by gut *Bacteroides* promotes sphingolipid synthesis and absorption, acting as a key source of sphingolipids in the body. The sphingosine metabolite 1-phosphosphingosine exerts complex regulatory effects by binding to diverse receptors. The sphingosine kinase signaling pathway, a key pathway involved in mast cell activation and inflammation, modulates downstream cytokines. It induces inflammatory mediators, thereby promoting the onset and progression of allergic rhinitis (AR). Wang et al¹⁷ proposed that the mechanism of SCIT involves exposing the body to significantly elevated allergen concentrations. Patients receive subcutaneous injections of allergen extracts, gradually building tolerance to

allergens. This indirectly influences the gut microbiota by promoting the growth of beneficial bacteria and suppressing the expansion of harmful bacteria, thereby regulating intestinal microecological balance. Subsequently, through the gut-immune axis to influence the systemic immune system. It induces immune tolerance through multiple pathways, including: impeding dendritic cell maturation; inducing the conversion of T_H0 cells to T_{reg} and T_H1 cells while suppressing T_H2 -related immune responses; and promoting B lymphocyte production of blocking IgG4 antibodies. This process regulates immune balance while progressively enhancing the body's immunotolerance to allergens. In healthy children, T_H1 and T_H2 cell subsets maintain a dynamic equilibrium. T_H1 cells participate in cellular immunity, while T_H2 cells are primarily associated with innate immunity and Type I hypersensitivity reactions. Under allergen exposure, the T_H1/T_H2 balance in AR patients is disrupted, leading to T_H2 hyperactivity. Such processes drive excessive cytokine release, increased airway hyper-responsiveness, and clinical manifestations including sneezing.¹⁸ Our study results suggest that SCIT confers substantial clinical benefits for patients with AR. Mechanistically, SCIT restores the T_H1/T_H2 equilibrium via elevating T_H1 -cell activity, which alleviates immune dysregulation stemming from excessive T_H2 -cell activation. In addition, it induces systemic allergen tolerance. Upon subsequent allergen re-exposure, patients maintain immune tolerance and avoid pronounced immune disturbance, which substantially relieves or even eliminates sneezing, rhinorrhoea and other related symptoms. These therapeutic effects are presumably mediated by modulating immune cells and their downstream signaling pathways to ameliorate clinical manifestations of AR, which aligns with prior observations reported by Specjalski K et al.¹⁹

Existing literature has documented sexual dimorphism in both innate and adaptive immune responses.²⁰ In the present cohort, the non-responsive subgroup contained a larger share of male patients relative to responders, and male sex was identified as a risk factor for SCIT treatment outcome ($OR > 1$, $p < 0.05$). Such disparity could be attributed to sex-related differences in immune profiles, including divergent T_H1/T_H2 cell equilibrium. Estrogen is well-established to potentiate immune activity, whereas androgens exert immunosuppressive properties. These immunological distinctions may partly explain the relatively weaker

SCIT responses observed in male patients. Yonghua et al.²¹ pointed out that allergic rhinitis arises from the interplay between environmental exposures and host genetic predisposition. Our results identified family history as another risk factor for SCIT response ($OR > 1$, $p < 0.05$). Genetic polymorphisms can modify immune reactivity, IgE synthesis and T_H2 -cell differentiation, which may blunt or even abolish the therapeutic response to SCIT. Furthermore, positive family history frequently correlates with more severe allergic phenotypes. Higher baseline disease severity and prolonged allergen exposure can drive the formation of stable, treatment-resistant immune phenotypes, which in turn compromises SCIT performance. Nevertheless, Helevä et al.²² found that family history of AR exerted no influence on the long-term therapeutic effects of specific immunotherapy. Accordingly, the exact influence of familial allergic predisposition on SCIT outcomes and its underlying mechanisms warrant further investigation. Prior investigations have shown that SCIT responses differ among AR patients living in distinct geographical settings, and urban dwelling acts as an independent risk factor, which is consistent with our observations.²³ This observation may be explained by elevated allergen burden within urban surroundings, especially for house-dust mites and pollens. High humidity and densely-packed residential buildings in cities provide ideal living conditions for house-dust mites, heightening individual allergen sensitization. Meanwhile, urban populations experience diminished microbial exposure, which predisposes individuals to immune dysregulation and impaired immune-regulatory function, resulting in suboptimal responses to immunotherapy and consequently compromising SCIT efficacy. This observation is in line with the work reported by Stefanovic et al.²⁴

A wealth of research has linked total IgE to type-I hypersensitivity. Upon antigen stimulation, B lymphocytes differentiate into plasma cells and generate antibodies that bind specifically to target antigens.^{25,26} Following initial exposure to house-dust-mite allergens, the immune system produces antibodies, among which sIgE serves as the main immunoglobulin driving allergic reactions. Chen et al.²⁷ noted that Grade-6 total IgE reflects a highly sensitized status, which points to over-activated T_H2 -mediated immunity. As a distinct T-cell subset, T_H2 cells secrete cytokines including interleukin-4 (IL-4) and IL-6. Excessive T_H2 activation suppresses keratinocyte differentiation and down-regulates skin-

barrier-related protein synthesis, compromising skin barrier integrity. This facilitates the infiltration of exogenous allergens and microbes, which in turn amplifies Th2-driven immune activation and sustains a pathological vicious cycle. Imbalanced Th1/Th2 homeostasis compromises the host's capacity to defend against allergens and pathogens, sustaining chronic inflammation. Such immunological status renders SCIT less manageable and raises the likelihood of therapeutic failure, which corroborates the results published by Komolafe et al.²⁸ Furthermore, Liao W et al.²⁹ demonstrated that Grade - 6 dust-mite-specific IgE corresponds to severe sensitization and elevates the risk of adverse treatment events. House-dust-mite allergens exhibit intrinsic protease activity. These proteases cleave allergen proteins into peptide fragments that are more efficiently captured and processed by antigen-presenting cells, facilitating antigen presentation to Th cells and triggering Th2-cell activation. Meanwhile, proteases target membrane receptors and intracellular signaling cascades to trigger the release of pro-inflammatory cytokines such as IL-4. These cytokines act as central mediators of Th2-cell-driven immunity, driving B-cell differentiation into plasma cells and boosting IgE antibody generation. This triggers a more intense immune reaction, which negatively impacts the efficacy of SCIT treatment in AR patients with hypersensitivity and increases the risk of treatment failure. Lane et al.³⁰ indicate that eosinophils (EOS) are a type of white blood cell closely associated with the immune system. In this study, EOS served as a risk factor for SCIT treatment efficacy in AR patients ($OR > 1$, $p < 0.05$). This is because eosinophils are key cells involved in allergic reactions. They release multiple inflammatory mediators that exacerbate inflammatory responses, leading to more severe rhinitis symptoms. A significant increase in eosinophil levels indicates a more intense allergic inflammatory response in the body. The release of cytokines and chemokines affects immune cell migration and activity through various signaling pathways (such as the NF- κ B pathway), thereby influencing the efficacy of immunotherapy, compromising skin barrier function, and facilitating easier entry of allergens and microorganisms into the skin. This activates the immune system, recruits and activates immune cells, disrupts immune regulation, and releases toxic inflammatory mediators, ultimately diminishing or causing failure of SCIT treatment outcomes.

The nomogram is a visual and user-friendly predictive instrument widely adopted in biomedical research and clinical scenarios, as it greatly improves the interpretability and clinical translational value of predictive models.³¹ In the present research, a nomogram was applied to visually display the predictive model for SCIT therapeutic response among children with AR based on multiple influencing indicators. The receiver operating characteristic (ROC) curve is a standard graphical approach for validating the performance of classification models. In this study, ROC analysis was performed to evaluate the predictive efficiency of screened variables for SCIT treatment outcomes, and the area under the curve (AUC) was calculated to quantify model accuracy. The final AUC value reached 0.924 (95% CI: 0.856 - 0.991), suggesting that the established model possesses excellent predictive performance and high consistency with real clinical outcomes. Nevertheless, several limitations of this study should be acknowledged. First, this research was designed as a single-center retrospective investigation. The relatively limited sample scale may cause statistical deviation from population characteristics, thereby restricting the external generalizability of the conclusions. Second, only pediatric patients aged under 16 years were included in the current cohort. Therefore, the derived findings are only applicable to children with allergic rhinitis and cannot be directly extended to adult populations. In addition, all enrolled participants were recruited from a unified geographical area, which may lead to homogeneity in ethnic background, living habits, and socioeconomic conditions. Such population homogeneity further constrains the applicability of the model to diverse regional and ethnic groups. Moreover, retrospective studies are inherently dependent on pre-existing electronic medical records and clinical datasets. Missing or incomplete raw data may inevitably exist during data collection, which could potentially affect the statistical stability and result reliability of this study. The nomogram model used in this study has not undergone external validation, and its potential for widespread adoption remains to be explored. The predictive model should be used solely as an auxiliary assessment tool, with clinical decisions requiring comprehensive consideration of individual circumstances. To address these limitations, future clinical studies should consider conducting multicenter, prospective research to expand sample sizes and conduct more in-depth exploration and

analysis of potential confounding factors that may influence outcomes, thereby providing a theoretical basis for clinical practice.

In summary, numerous factors influence the efficacy of SCIT treatment in AR patients, including sex, family history, place of residence, total IgE, dust mite sIgE, and eosinophil count. These indicators can facilitate clinical screening of high-risk populations and provide a theoretical reference for implementing corresponding prevention and control strategies.

STATEMENT OF ETHICS

This study was approved by the Institutional Review Board and Ethics Committee. Given its retrospective nature and use of de-identified patient data, informed consent was not required as it posed no risk or adverse impact on patient care. This exemption complies with regulations and ethical guidelines pertaining to retrospective research.

FUNDING

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

ACKNOWLEDGMENTS

Not applicable.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author upon reasonable request.

AI ASSISTANCE DISCLOSURE

Not applicable.

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