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ARTICLE

Effects of Parental Cognitive Enhancement Combined with Parent–Child Psychological Support on Symptom Control and Prognosis in Children with Allergic Rhinitis

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ABSTRACT: Objectives: Pediatric allergic rhinitis (AR) is a highly prevalent chronic inflammatory airway disease that significantly impairs children's sleep, learning performance, and quality of life. Despite standardized pharmacotherapy, long-term symptom control remains suboptimal, which is related to the poor treatment compliance of patients and the insufficient disease awareness of parents. This study aimed to evaluate the effects of parental cognitive enhancement combined with parent–child psychological support on symptom control, the quality of life, and underlying intervention mechanisms in children aged 6–14 years with moderate to severe AR. **Methods:** A total of 150 children aged 6–14 years with moderate to severe AR and their primary caregivers were enrolled and allocated to a study or a control group. The control group received routine home management for AR, and the study group received a combined intervention of parental cognitive enhancement and parent–child psychological support in addition to routine management. Total Nasal Symptom Score (TNSS), quality of life assessed by the Pediatric Rhinoconjunctivitis Quality of Life Questionnaire (PRQLQ), and medication adherence assessed by the 8-item Morisky Medication Adherence Scale were compared between the two groups before and after intervention. Evaluation was also conducted on the parental cognitive level, anxiety status assessed by the Self-Rating Anxiety Scale (SAS), and parent–child relationship assessed by the Child–Parent Relationship Scale were also evaluated. The bootstrap method was used to analyze the mediating effects of parental cognition and parent–child relationship. **Results:** After intervention, the study group showed significantly lower TNSS, PRQLQ scores in children, parental SAS scores, and parent–child conflict than the control group (all $p < 0.05$) and significantly higher medication adherence, parental cognitive scores, and parent–child closeness (all $p < 0.05$). Mediation analysis showed that the direct effect of study grouping on TNSS was not significant ($p = 0.512$), whereas the indirect effects mediated through "parental cognitive level" and "parent–child relationship" were significant (95% confidence interval did not include 0), which indicates that the intervention effect was statistically mediated through these pathways. **Conclusions:** The combined intervention of parental cognitive enhancement and parent–child psychological support effectively improves clinical symptoms in children with moderate to severe AR, treatment adherence, and the quality of life.

KEYWORDS: Allergic rhinitis; parental cognition; parent–child psychological support; quality of life; mediating effect

1 Introduction

Pediatric allergic rhinitis (AR) refers to a common chronic inflammatory disease of the respiratory tract in clinical pediatric practice. The typical nasal symptoms of AR, such as nasal congestion, rhinorrhea, and sneezing, and accompanying ocular symptoms not only cause remarkable physical discomfort in affected

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children but also markedly impair attention, daily functioning, and sleep quality [1–3]. Currently, the clinical management of AR primarily involves a comprehensive approach integrating environmental control, pharmacotherapy, immunotherapy, and health education [4,5]. However, as a result of the chronic and recurrent nature of AR, adherence management during long-term treatment has become a key determinant of prognosis [6,7]. Given the young age of pediatric patients and their limited capacity for self-management, the level of disease control largely depends on parental cognition and caregiving competence [8,9]. Clinical observations indicate that some parents lack adequate scientific understanding of the etiology of AR, standardized medication use, and environmental avoidance strategies [10,11]. Consequently, behaviors such as unauthorized discontinuation of medication, inappropriate use of antibiotics, or neglect of environmental control measures commonly occur, which lead to poor symptom control and repeated medical visits among affected children [12,13].

Moreover, the persistent burden of chronic disease not only compromises children's emotional stability, contributing to psychological problems such as anxiety and depression, but also imposes substantial psychological stress on parents [14–16]. Maladaptive emotional interactions within the parent–child relationship may create a vicious cycle, which reduces treatment adherence and exacerbates clinical symptoms [17,18]. From the perspective of the biopsychosocial medical model, reliance on pharmacological treatment alone is insufficient to meet current clinical needs. Integration of parental cognitive interventions with in-depth parent–child psychological support may represent a novel approach to improving AR management outcomes [19,20]. To date, evidence regarding the combined effects of these interventions on therapeutic outcomes in children with AR remains limited. Therefore, the present study aimed to investigate the effect of parental cognitive enhancement combined with parent–child psychological support on symptom control in pediatric AR, with the goal of providing an optimized chronic disease management strategy for clinical practice. We proposed the following research hypotheses (Fig. 1): Hypothesis 1 (H1): The combined intervention will significantly improve nasal symptoms and the quality of life in children with AR compared with routine management. H2: The combined intervention will improve medication adherence and symptom control by enhancing parental disease-related cognitive levels. H3: The combined intervention will reduce symptom severity by improving the parent–child relationship. H4: Parental cognitive level and the parent–child relationship act as parallel mediators in the association between the intervention and AR symptom control.

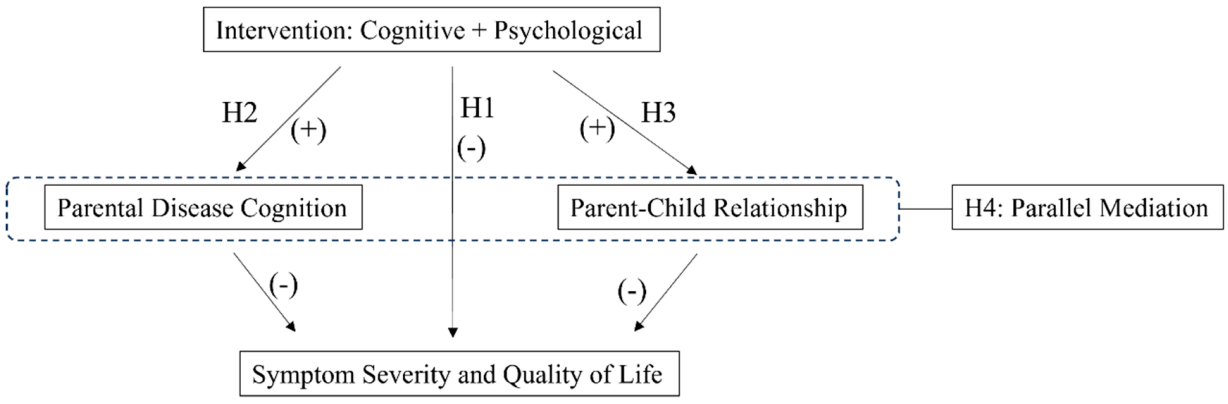

Figure 1: Hypothetical conceptual model. H, Hypotheses. The (+) sign indicates a hypothesized positive effect; the (–) sign indicates a hypothesized negative effect.

2 Participants and Methods

2.1 Participants

In this prospective research, children aged 6–14 years with moderate to severe AR, along with their primary caregivers (parents providing at least 4 h of daily care), were enrolled from the Outpatient Department of Otolaryngology at Ma'anshan Maternal and Child Health Care Hospital between January and December 2024. Based on the primary outcome (TNSS), with a two-sided α of 0.05 and a power $(1 - \beta)$ of 0.80, the calculated minimum sample size was 63 per group. Accounting for a 15% dropout rate, the final total sample size was 150. A per-protocol analysis was adopted, and recruitment continued until 75 participants had been allocated per group to complete the study to ensure statistical power. Participants were randomly assigned at a 1:1 ratio to either the study group (n = 75), which received routine AR home management combined with parental cognitive improvement and parent–child psychological support, or the control group (n = 75), which received routine AR home management only. Randomization was performed using a computer-generated random number sequence produced by SPSS 26.0 (International Business Machines Corporation (IBM), Armonk, New York, USA). Allocation concealment was ensured using consecutively numbered, opaque, sealed envelopes, which were opened by a research assistant not involved in recruitment only after baseline assessment was completed. Given the nature of the behavioral intervention, blinding of the participants or the intervention nurses to group allocation was not possible. However, to minimize detection bias, we blinded the outcome assessors and the data analysts to the grouping. Regarding potential attention bias, the study group received additional WeChat-based interaction, and the control group received weekly telephone follow-ups from healthcare staff to ensure a comparable level of professional contact and care.

The inclusion criteria were as follows: (1) met the diagnostic criteria for persistent moderate to severe AR as outlined in the Chinese Guideline for Diagnosis and Treatment of Allergic Rhinitis (2022, revision) [21]; (2) Visual Analog Scale score ≥ 4; (3) families able to cooperate with a 6-month follow-up, including outpatient visits or telephone follow-up; (4) informed consent obtained from parents and children, with signed informed consent forms. The exclusion criteria comprised the following: (1) children with nasal polyps or severe nasal septal deviation; (2) children with intellectual disability, psychiatric disorders, or severe systemic diseases involving the heart, liver, or kidneys; (3) parents with psychiatric or psychological disorders, communication barriers, or insufficient caregiving capacity; (4) families experiencing major adverse events during the study period.

This study was approved by the Ethics Committee of Ma'anshan Maternal and Child Health Care Hospital (NO. PJ-2023-29), and informed consent forms were obtained from the legal guardians of all the patients.

2.2 Interventions

The control group received routine AR home management only. In addition to the routine management, the study group received a dual-dimensional intervention consisting of parental cognitive improvement and parent–child psychological support. The specific measures are as follows:

Control group: (1) medication guidance: instruction on the correct use of intranasal corticosteroids and/or antihistamines, with illustrated educational brochures provided; (2) allergen avoidance: environmental control guidance based on allergen type (e.g., house dust mites or pollen), such as washing bedding at 55°C and wearing masks during the pollen season; (3) symptom monitoring: parents were instructed to complete an AR symptom diary, and community healthcare staff conducted weekly telephone follow-up.

Study group: The combined intervention was delivered by specialist pediatric nurses who underwent 10 h of standardized training on AR guidelines and psychological communication techniques. Over the 6-month period, the frequency of contact included one initial face-to-face session (45 min) and weekly WeChat-based interactions (20–25 min/week), which resulted in an estimated total professional contact time of 9–11 h per family.

(1) Parental cognitive enhancement: ① Theoretical education: a self-developed Parental Cognitive Handbook for the Prevention and Management of Pediatric Allergic Rhinitis was distributed. Together with popular science animated videos, AR immunopathological mechanisms were explained in a clear and accessible manner. The concept of "one airway, one disease" was emphasized, and the pathological association between nasal symptoms and ocular symptoms (e.g., ocular itching and conjunctival hyperemia) was elucidated to enhance parental awareness of comorbid conditions. ② Correction of misconceptions: Common parental misconceptions, such as "steroid phobia" and "discontinuing medication once symptoms disappear", were addressed. The local safety profile of intranasal corticosteroids and their extremely low systemic bioavailability were explained to improve parental acceptance of long-term standardized treatment. ③ Nasal irrigation training: Specialist nurses demonstrated standard nasal irrigation techniques using nasal irrigation device models; such techniques included correct posture (leaning forward with mouth breathing), appropriate water temperature, and saline concentration preparation. Parents were then required to perform simulated operations, and nurses provided immediate feedback and correction for issues, such as excessive irrigation pressure or incorrect posture, until the techniques were fully standardized. ④ WeChat-based Study group: A dedicated WeChat group was established to deliver weekly case-based analyses (e.g., "Why does ear pain occur after nasal irrigation?" and "How to distinguish a common cold from allergic rhinitis?"). Common caregiving problems encountered by parents during home management were collected and addressed through unified, expert-led responses.

(2) Parent–child psychological support: ① Identification of symptom–emotion associations: Parents were guided to recognize the causal links between AR-related somatic symptoms, such as reduced sleep quality resulting from persistent nasal congestion and impaired concentration caused by ocular itching, and children's behavioral problems, including irritability, emotional lability, low self-esteem, and social withdrawal. Parents were instructed to record the child's daily nasal symptom scores together with same-day emotional and behavioral manifestations. Through continuous and systematic recording, parents intuitively identified the pattern whereby symptom exacerbation precipitated emotional fluctuations. This process facilitated a shift from "simply blaming the child for noncompliance" to "understanding the child's illness-related discomfort", which laid a solid foundation for subsequent emotional support. ② Gamified parent–child interaction strategies: A "nasal breathing relaxation game" was introduced. Guided by standardized instructional videos, parents led children to perform diaphragmatic breathing exercises and nasal ala massage. This approach not only helped alleviate nasal obstruction but also improved secure parent–child attachment through positive physical contact. For treatment procedures commonly resisted by children, such as nasal irrigation and intranasal medication administration, parents implemented immediate positive reinforcement using reward stickers. Each successful completion of a treatment session earned the child a "bravery badge", which can be exchanged for a desired reward once a predetermined number had been accumulated. ③ Bidirectional emotional guidance and empowerment: For situations in which children cried or resisted medication administration, parents were provided with a communication script manual. They were instructed to apply an "empathy-validation-action" communication model (e.g., "I know the nasal

spray feels uncomfortable; Mommy will count to three with you, and it will be over soon"), which replaced traditional coercive or threatening language and thereby reduced children's psychological stress responses. To address parental anxiety arising from recurrent disease episodes, we taught parents the "5-4-3-2-1 grounding technique" for stress reduction. Portable stress-relief cards were distributed to guide parents in rapid self-regulation before emotional escalation, which prevented the transmission of anxiety to the child through emotional contagion and fostered an emotionally stable family-based rehabilitation environment.

2.3 Outcome Measures

2.3.1 Primary Outcome

The severity of nasal symptoms of AR was assessed using the Total Nasal Symptom Score (TNSS) [22]. The TNSS comprises four nasal symptom items: sneezing, rhinorrhea, nasal itching, and nasal obstruction. Each item is rated on a 4-point scale ranging from 0 to 3 based on symptom severity. The TNSS is calculated as the sum of the scores for the four items, with a total score ranging from 0 to 12. High TNSS values indicate severe nasal symptoms. The TNSS had a Cronbach's α coefficient of 0.80.

2.3.2 Secondary Outcomes

(1) Pediatric Rhinoconjunctivitis Quality of Life Questionnaire (PRQLQ) [23]: The validated Chinese version of the PRQLQ was used to evaluate impairment in the quality of life resulting from nasal and ocular symptoms. The PRQLQ comprises five domains: nasal symptoms, ocular symptoms, nonspecific symptoms, activity/behavioral problems, and other symptoms (sleep and emotional functioning), with a total of 23 items. Each item is scored on a 7-point scale ranging from 0 ("never") to 6 ("always"). High total scores indicate a poor quality of life. The PRQLQ had a Cronbach's α coefficient of 0.90.

(2) Parental Disease-Related Cognitive Level: Parental cognition was assessed using a self-developed parental cognition and caregiving ability questionnaire for pediatric AR. The development of this instrument followed a rigorous process: (1) Item Generation: An initial item pool was created based on the Chinese Guideline for Diagnosis and Treatment of Allergic Rhinitis (2022, revision) and a review of relevant literature, combined with high-frequency questions collected from clinical nursing practice. (2) Expert Consultation and Validation: A panel of five experts (associate chief otolaryngologists and senior pediatric nurses) reviewed the items for importance, clarity, and relevance. (3) Pilot Testing: A pilot test was conducted on 30 parents not included in the main study to ensure that the questions were intelligible and feasible. The final questionnaire consisted of 12 items covering four domains: disease pathophysiology (e.g., understanding the "One Airway, One Disease" concept), standardized pharmacological treatment (e.g., correcting misconceptions about intranasal corticosteroids), home care skills (e.g., proper nozzle orientation for nasal sprays), and environmental and psychological management. A binary scoring system was used: 1 point for a correct answer and 0 point for an incorrect or "unsure" answer (total score range: 0–12). High scores indicate desirable disease-related cognition. Given that this instrument functions as a formative knowledge index covering diverse clinical skills rather than a latent psychological construct, validation prioritized content validity. The item-level content validity index (CVI) ranged from 0.80 to 1.00, and the scale-level CVI was 0.92. The Cronbach's α coefficient was 0.82, which indicated good validity and reliability.

(3) Self-Rating Anxiety Scale (SAS): Parental anxiety during caregiving was assessed using the Chinese version of the Zung SAS. The scale contains 20 items, with each rated on a 4-point Likert scale (1–4 points). The sum of item scores was multiplied by 1.25 to obtain a standardized score ranging

from 25 to 100. A standardized score <50 indicates no anxiety; 50–59 denotes mild anxiety; 60–69 means moderate anxiety; ≥70 corresponds to severe anxiety. SAS had a Cronbach's α coefficient equal to 0.81.

(4) Child–Parent Relationship Scale (CPRS) [24]: The validated Chinese short version of the CPRS was used; it consists of two dimensions, namely, closeness (7 items) and conflict (8 items), for a total of 15 items. Items are rated on a 5-point Likert scale from 1 ("strongly disagree") to 5 ("strongly agree"), and mean scores are calculated for each dimension. High closeness scores indicate a harmonious parent–child relationship and strong emotional bonding, whereas high conflict scores indicate great friction and tension in parent–child interactions. The Cronbach's α coefficients for the closeness and conflict subscales were 0.84 and 0.80, respectively.

(5) Morisky Medication Adherence Scale (MMAS-8) [25,26]: The 8-item MMAS-8was used to assess medication adherence behaviors in children under parental supervision. The scale addresses common nonadherence scenarios, including forgetting to take medication, discontinuing medication during symptom improvement, and stopping medication when symptoms worsen. The total score ranges from 0 to 8, with scores <6 indicating low adherence, 6–7 indicating medium adherence, and 8 indicating high adherence. The MMAS-8 had a Cronbach's α coefficient of 0.79.

2.4 Statistical Analysis

All data were analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Normality of continuous variables was initially assessed using Shapiro–Wilk test, and homogeneity of variance was evaluated using Levene's test. Normally distributed continuous variables are presented as mean ± standard deviation ($\bar{x} \pm s$). Between-group comparisons were performed using independent-sample t test, and within-group comparisons were conducted using paired-sample t test. Effect sizes for parametric comparisons were reported as Cohen's d (0.2 = small, 0.5 = medium, 0.8 = large). Non-normally distributed continuous variables are presented as median (interquartile range). Between-group comparisons were performed using Mann–Whitney U test, and within-group comparisons were conducted using Wilcoxon signed-rank test. Categorical variables are presented as number (%), and between-group comparisons were performed using chi-square (χ^2) test or Fisher's exact test, as appropriate. Mediation effects were examined using Model 4 in the PROCESS macro (Version 3.5) for SPSS. Mediation analysis was performed based on 5000 bootstrap resamples to generate bias-corrected 95% confidence intervals (CI). A pathway was considered significant if the 95% CI did not include zero. A two-sided p value < 0.05 was considered statistically significant.

3 Results

3.1 Baseline Characteristics

No statistically significant differences were observed between the two groups in terms of age, sex, disease duration, allergen type, presence of a family history, or parental educational level (all $p > 0.05$). Table 1 presents the baseline characteristics of the children.

3.2 Comparison of Clinical Symptoms (Addressing Hypothesis 1)

Before the intervention, no statistically significant differences were detected in the TNSS scores between the two groups (all $p > 0.05$). After the intervention, both groups showed significant reductions in TNSS scores compared with baseline (all $p < 0.001$). Between-group comparisons demonstrated significantly lower TNSS scores in the study group compared with those in the control group (all $p < 0.05$, Fig. 2).

The analysis indicated a small-to-medium effect size (Cohen's d = 0.37), which suggests a moderate but statistically significant improvement in symptom control beyond routine care.

Table 1: Baseline characteristics of the children included in the study [median (P25, P75), $\bar{x} \pm s$, n (%)].

Variables	Control Group (n = 75)	Study Group (n = 75)	Z/t/χ^2	p
Age	11 (8, 12)	10 (8, 12)	−0.545	0.586
Sex			/	0.414
Male	36 (48.00)	42 (56.00)		
Female	39 (52.00)	33 (44.00)		
Disease duration (years)	3.79 ± 1.58	4.00 ± 1.78	0.781	0.436
Allergen type			1.355	0.508
House dust mites	48 (64.00)	41 (54.67)		
Pollen	11 (14.67)	14 (18.67)		
Others	16 (21.33)	20 (26.67)		
Family history			/	0.327
Yes	35 (46.67)	42 (56.00)		
No	40 (53.33)	33 (44.00)		
Parental educational level			0.836	0.658
Junior high school or below	12 (16.00)	9 (12.00)		
Senior high school/secondary technical school	28 (37.33)	26 (34.67)		
Junior college or above	35 (46.67)	40 (53.33)		

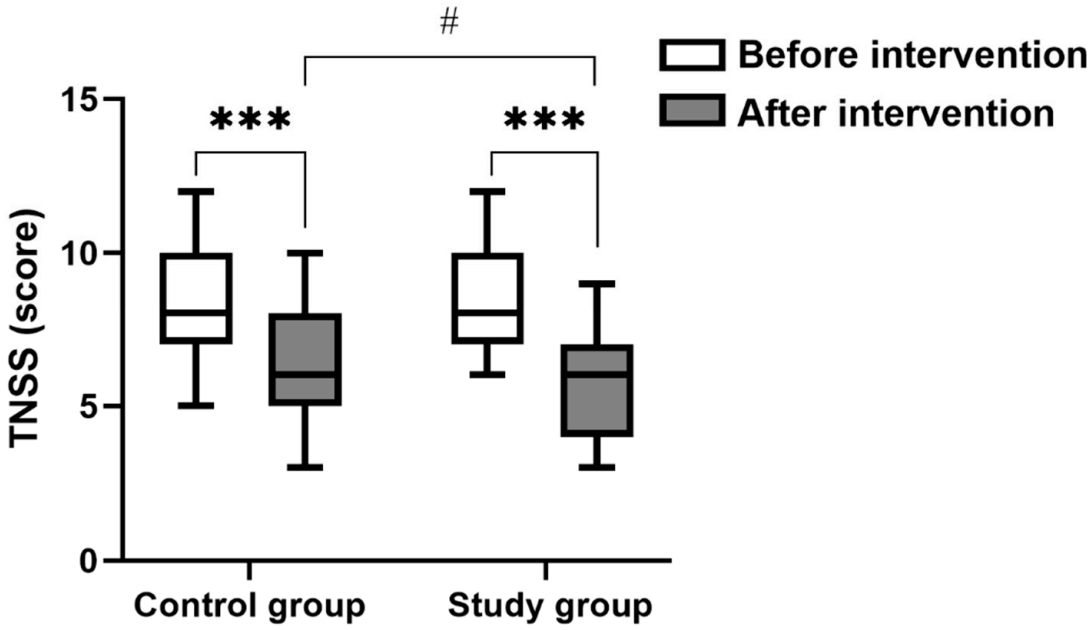

Figure 2: Comparison of clinical symptom scores between the two groups before and after the intervention. TNSS, Total Nasal Symptom Score. *** indicates $p < 0.001$ compared with the same group before intervention; # indicates $p < 0.05$ compared with the control group.

3.3 Comparison of the Quality of Life (Addressing Hypothesis 1)

Before the intervention, no statistically significant differences were observed between the two groups in terms of the PRQLQ domain scores or total scores (all $p > 0.05$). After the intervention, the control group showed significantly reduced scores across all PRQLQ domains (nasal symptoms, ocular symptoms,

nonspecific symptoms, activity/behavioral problems, and other symptoms) compared with the baseline, with the total score decreasing from 66.65 ± 8.01 to 43.67 ± 6.83 ($p < 0.001$). In the study group, quality-of-life scores were slightly higher at baseline than those in the control group, and all domain scores showed marked improvement after the intervention, with the total score decreasing from 68.52 ± 8.02 to 36.83 ± 4.86 ($p < 0.001$). Between-group comparisons demonstrated that after the intervention, the study group achieved significantly lower PRQLQ total score and domain scores than the control group (all $p < 0.05$) (Table 2). Notably, the intervention demonstrated a large effect size on the improvement of the overall quality of life (Cohen's $d = 1.16$ for total PRQLQ score).

Table 2: Comparison of PRQLQ scores between the two groups before and after the intervention ($\bar{x} \pm s$, point).

Indicators	Control Group ($n = 75$)		Study Group ($n = 75$)	
	Before Intervention	After Intervention	Before Intervention	After Intervention
Nasal symptoms	18.83 ± 4.45	12.93 ± 2.57***	17.97 ± 4.25	11.12 ± 1.88***###
Ocular symptoms	17.33 ± 4.27	10.23 ± 3.15***	18.05 ± 3.42	8.48 ± 2.72***###
Non-specific symptoms	12.84 ± 3.65	9.31 ± 2.78***	13.67 ± 3.83	7.89 ± 2.13***###
Behavioral problems	7.67 ± 4.01	5.37 ± 3.22***	8.47 ± 3.64	4.43 ± 2.34***#
Other symptoms	9.99 ± 2.50	5.83 ± 2.97***	10.36 ± 2.54	4.91 ± 2.14***#
Total score	66.65 ± 8.01	43.67 ± 6.83***	68.52 ± 8.02	36.83 ± 4.86***###

PRQLQ, Pediatric Rhinoconjunctivitis Quality of Life Questionnaire; *** indicates $p < 0.001$ compared with the same group before intervention; # indicates $p < 0.05$ compared with the control group; ### indicates $p < 0.001$ compared with the control group.

3.4 Comparison of Parental Disease Cognition, Parental Psychological Status, Parent–Child Relationship, and Children's Medication Adherence (Addressing Hypotheses 2 and 3)

Before the intervention, no significant differences were noticed between the control and study groups in terms of children's medication adherence, parental disease-related cognition, parental anxiety levels, or parent–child relationship scores (all $p > 0.05$). After the intervention, all the above indicators showed significant improvement in both groups compared with the baseline (all $p < 0.01$). Furthermore, compared with the control group, the study group demonstrated significantly higher levels of children's medication adherence, parental disease-related cognition, and parent–child closeness (all $p < 0.001$) and significantly lower parental anxiety levels and parent–child conflict scores (all $p < 0.001$) (Table 3).

Table 3: Comparison of parental disease cognition, parental anxiety levels, parent–child relationship, and children's medication adherence between the two groups [median (P25, P75), $\bar{x} \pm s$, point].

Indicators	Control Group ($n = 75$)		Study Group ($n = 75$)	
	Before Intervention	After Intervention	Before Intervention	After Intervention
MMAS-8 score (children)	5 (4, 6)	6 (5, 7)***	5 (4, 6)	7 (6, 8)***###
Parental disease-related cognitive level	6 (5, 8)	9 (8, 10)***	7 (5, 9)	11 (9, 12)***###
SAS score (Parent)	60.82 ± 8.37	52.02 ± 6.84***	62.68 ± 9.94	43.28 ± 7.41***###
CPRS				
Closeness	23.55 ± 5.82	25.81 ± 3.91**	21.89 ± 4.98	28.76 ± 3.83***###
Conflict	24.39 ± 5.05	20.04 ± 4.88***	25.24 ± 4.29	16.81 ± 4.42***###

SAS, Self-Rating Anxiety Scale; CPRS, Child–Parent Relationship Scale; MMAS-8, 8-item Morisky Medication Adherence Scale. ** indicates $p < 0.01$ compared with the same group before intervention; *** indicates $p < 0.001$ compared with the same group before intervention; ### indicates $p < 0.001$ compared with the control group.

3.5 Mediation Effect Analysis (Testing Hypotheses 2, 3, and 4)

To further elucidate the underlying mechanisms by which parental cognitive enhancement combined with parent–child psychological support improved TNSS in children, we constructed a parallel multiple mediation model using group allocation as the independent variable (X), parental cognitive level (M1) and parent–child relationship closeness (M2) as mediating variables, and TNSS score as the dependent variable (Y). Mediation analysis was performed using Model 4 of the SPSS PROCESS macro. Fig. 3 presents the results of path analysis.

The total effect of the intervention on TNSS was −0.65 (p = 0.027), with a 95% CI (−1.23 to −0.08) that did not include zero, which indicates that the intervention significantly improved nasal symptoms overall. The direct effect of group allocation on TNSS was −0.21 (p = 0.512), with a 95% CI (−0.83 to 0.42) that included zero, which suggests that the direct effect of the intervention on symptom improvement was not statistically significant when mediating variables were disregarded.

By contrast, the indirect effect mediated through parental cognitive level and parent–child relationship closeness was −0.45 (95% CI did not include 0) (Table 4). This finding indicates significant indirect effects, which implies that the beneficial impact of the intervention on symptom improvement was largely explained by the enhancement of parental disease-related cognition and the improvement of the parent–child relationship.

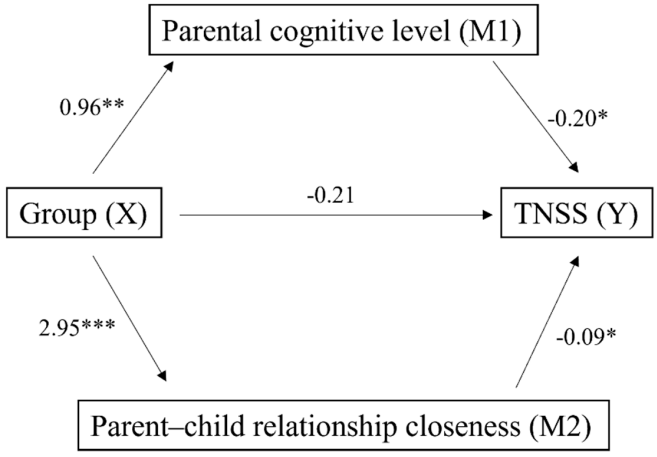

Figure 3: Path diagram of mediation effect analysis. TNSS, Total Nasal Symptom Score. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

Table 4: Total, direct, and indirect mediation effects.

Effect Type	Path	Effect Estimate	SE	LLCI	ULCI	*p*	Proportion of the Total Effect
Total effect	X → Y	−0.65	0.29	−1.23	−0.08	0.027	100%
Direct effect	X → Y	−0.21	0.32	−0.83	0.42	0.512	31.8%
Mediation effect	X → M1, M2 → Y	−0.45	0.17	−0.81	−0.15	/	68.2%
Indirect effect 1	X → M1 → Y	−0.19	0.11	−0.43	−0.00	/	28.9%
Indirect effect 2	X → M2 → Y	−0.26	0.13	−0.53	−0.04	/	39.3%

X, group allocation; Y, Total Nasal Symptom Score (TNSS); M1, parental cognitive level; M2, parent–child relationship closeness; LLCI, lower limit of the confidence interval; ULCI, upper limit of the confidence interval; SE, Standard Error.

3.6 Hypothesis Verification

Based on the statistical findings presented above, the research hypotheses proposed in this study were verified as follows:

H1 was supported: The study group demonstrated significantly lower TNSS and PRQLQ scores compared with the control group (all $p < 0.05$), which confirmed the overall efficacy of the combined intervention.

H2 was supported: Mediation analysis revealed a significant specific indirect effect via parental disease-related cognitive level (95% CI: −0.430 to −0.004), which verified that cognition enhancement contributes to symptom control.

H3 was supported: The specific indirect effect via the parent–child relationship was significant (95% CI: −0.532 to −0.043), which confirms that improvement of the parent–child relationship reduces symptom severity.

H4 was supported: The parallel mediation model was successfully validated, which indicates that parental cognition and the parent-child relationship act as parallel mediators in the association between the intervention and AR symptom control.

4 Discussion

The present study demonstrated that on the basis of routine pharmacological treatment, an intervention model combining parental cognitive enhancement with parent–child psychological support can significantly improve clinical symptoms in children aged 6–14 years with moderate to severe AR [27]. The results show that after the intervention, the study group achieved significantly lower TNSS scores than the control group. These findings directly address a common challenge in pediatric clinical practice, that is, pharmacological therapy alone is often insufficient to achieve optimal symptom control in children with moderate to severe AR. In addition, the improvement in the quality of life, Ias assessed by the PRQLQ, was markedly greater in the study group than in the control group. Notably, the former showed particular advantages in the "other symptoms" domain, which includes manifestations such as irritability and fatigue. This outcome suggests that the combined intervention exerts a synergistic effect by simultaneously addressing physical and psychological dimensions of the disease. In such a manner, it effectively disrupts the vicious cycle between poor symptom control and deterioration in the quality of life.

With regard to the underlying mechanisms of this intervention, enhanced parental cognition plays a critical role in improving treatment adherence and promoting standardized disease management. Parental misconceptions about AR—such as fear of corticosteroids and discontinuation of medication once symptoms subside—serve as major contributors to disease recurrence and poor symptom control in children [28–30]. In the present study, feedback-based skill training and continuous online consultation were employed to translate abstract guideline recommendations into practical caregiving skills, such as adopting the correct posture for nasal irrigation and ensuring appropriate spray orientation for intranasal medications. This effective transition from "knowledge" to "practice" helped in preventing treatment failure or adverse effects caused by improper techniques and ensured sustained and precise drug delivery to target tissues [31]. Consequently, a positive feedback loop characterized by "enhanced parental cognition-improved child adherence-marked alleviation of AR symptoms" was established.

However, symptom control in AR is not solely dependent on pharmacological treatment; instead, it also shows a close relation to psychological factors [32–34]. In the present work, parents in the study group exhibited significantly lower SAS scores, along with increased closeness and reduced conflict on the CPRS. According to the biopsychosocial medical model, elevated parental anxiety can be transmitted to children through mechanisms of "emotional contagion", which induces psychological stress in affected children.

Psychological stress activates the hypothalamic–pituitary–adrenal (HPA) axis, which leads to dysregulation of cortisol secretion [35,36]. Aberrant cortisol levels can fail to effectively suppress inflammation and may induce a shift toward a T-helper 2-dominant immune response, which is characterized by increased release of cytokines, such as interleukin (IL)-4, IL-5, and IL-13 [37,38]. This immunological shift promotes IgE synthesis and eosinophil activation, which exacerbates nasal mucosal inflammation and clinical symptoms. Conversely, the reduction of anxiety and the promotion of relaxation through parent–child psychological support may help in the restoration of HPA axis balance, decreasing pro-inflammatory signaling, and synergistic enhancement of the efficacy of pharmacotherapy [39–41]. Aligning with family systems theory, which views the family as an interconnected emotional unit, our results suggest that stabilizing the "parental subsystem" effectively downregulates stress in the "child subsystem." This finding validates the necessity of shifting from a child-centric to a family-centered biopsychosocial model in pediatric care.

Comparison with previous studies highlights the innovative nature of this dual-dimensional intervention. Although psychosocial interventions have been extensively studied in pediatric asthma management—demonstrating significant reductions in parental stress and symptom severity [15,39]—similar integrated approaches in AR remain relatively scarce. Previous AR interventions, such as the family-centered care model proposed by Pan et al. [31], primarily focused on improving medication compliance through health education and environmental control. Although effective in the short term, these "single-dimensional" cognitive interventions often overlook the emotional barriers to adherence, such as child resistance and parental anxiety. In contrast to these traditional approaches, our study integrated "parental cognitive enhancement" with "parent-child psychological support." By incorporating specific strategies such as "gamified interaction" and "bidirectional emotional guidance", our intervention not only corrects caregiving misconceptions but also actively repairs the parent–child relationship. This comparison suggests that the superior outcomes observed in our study may stem from the synergistic effect of addressing the "technical" (cognition) and "emotional" (psychological) burdens of the disease, rather than treating them in isolation.

In this study, mediation analysis was performed to quantify the mechanisms underlying the observed effects. Path analysis demonstrated that the direct effect of group allocation on TNSS was not statistically significant, whereas the indirect effects mediated through parental cognitive level and the parent–child relationship were significant, which indicate significant indirect effects. This finding suggests that the therapeutic benefits of the intervention were largely explained by improvements in parental cognition and the quality of the parent–child relationship. Notably, the proportion of the mediating effect attributable to the parent–child relationship (39.3%) was greater than that attributable to parental cognitive level (28.9%). This observation implies important clinical implications: in the management of chronic diseases in children, fostering a harmonious and supportive family emotional environment may be more critical than knowledge dissemination alone [42–44]. A positive parent–child relationship can enhance treatment adherence, increase children's acceptance of long-term therapy, reduce resistance behaviors, such as crying or opposition during treatment, and ultimately facilitate the implementation of therapeutic regimens [45].

Several limitations of this study should be acknowledged. First, the sample was derived from a single center, which may introduce selection bias. In addition, long-term follow-up was not conducted. Given the pronounced seasonal variability of AR, extended observation periods are necessary for the adequate evaluation of long-term outcomes. Second, psychological status was primarily assessed using self-report questionnaires, and objective physiological stress indicators, such as cortisol levels, were excluded. Third, given the nature of the psychological intervention, a double-blind design was not feasible. Although we employed blinded outcome assessors and provided weekly telephone follow-ups for the control group to balance professional attention, the risk of expectancy bias or the Hawthorne effect cannot be entirely

ruled out. Fourth, key outcomes, such as medication adherence (MMAS-8) and psychological status (SAS and CPRS), were assessed using self-reported questionnaires. Although validated tools were used, the results may still be subject to recall bias or social desirability bias (i.e., parents overestimating adherence to please the researchers). Finally, this research was conducted in Anhui, China, within a specific cultural context where intergenerational involvement in caregiving is high. Therefore, the generalizability of these findings to other cultural settings or healthcare systems with different parent–child dynamics requires further verification.

5 Conclusion

The combination of parental cognitive enhancement and parent–child psychological support represents a scientific and effective management strategy for pediatric AR. This intervention model contributes to improved nasal symptom control, enhanced quality of life in children, increased parental disease-related cognition, and strengthened parent–child relationships. Owing to its low cost, high benefit, and ease of implementation, this approach is well suited for broader application in pediatric chronic disease management, which facilitated a shift from a purely biological treatment paradigm toward an integrated biological, psychological, and family-centered intervention model. This finding provides promising evidence for integrated care models, though multicenter trials are needed to confirm their long-term efficacy.

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Ethics Approval: This study was approved by the Ethics Committee of Ma'anshan Maternal and Child Health Care Hospital (No. PJ-2023-29), and informed consent forms were obtained from the legal guardians of all the patients.

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