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Assessment Of The Efficacy And Safety Of Pharmacotherapeutic Agents In The Management Of Allergic Rhinitis

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Abstract
Allergic rhinitis (AR) is a prevalent condition affecting 30% of the Indian population, with significant morbidity, socioeconomic impact, and under-optimized treatment. Despite various therapies, the management of AR remains suboptimal due to several barriers.
To evaluate the efficacy and safety of commonly prescribed pharmacotherapeutic agents, including oral/intranasal antihistamines, intranasal corticosteroids, and immunotherapies (subcutaneous and sublingual), in AR management.
A 12-month prospective observational study was conducted at a tertiary care hospital in India. Patients with a clinical diagnosis of AR were recruited and treated as per their physician's prescriptions. Efficacy was assessed using the Total Nasal Symptom Score (TNSS) and Rhino conjunctivitis Quality of Life Questionnaire (RQLQ). Safety data and adverse events were also analyzed. Among 230 participants, intranasal corticosteroids (INCS) showed the most significant symptom reduction (71%) and quality of life improvement (61%), followed by subcutaneous (66%) and sublingual (63%) immunotherapy. Adverse events were minimal, with SCIT associated with localized injection reactions. INCS was found as the most effective therapy for AR management, followed by immunotherapies. Tailored treatments based on symptom severity and patient preferences are crucial for optimal outcomes.
Key words: *Allergic rhinitis Intranasal corticosteroids, over the counter drugs, Asthma and Allergies in Childhood*

INTRODUCTION

Allergic rhinitis (AR) is an allergen-induced, upper-airway inflammatory disease characterised by hyperreactive airway mucosa. Traditionally it is considered as a localised condition of the nose and nasal passage. However, recent clinical evidence presents that AR is linked to other airway diseases making it systemic **(Bousquet J, 2020), (Alnahas S et al., 2019)**. An estimated 400 million people worldwide suffer from AR, a recurrent disease which persists throughout the life. Although AR symptoms exist, many people choose to self-treat the condition with over the counter (OTC) drugs and home remedies. Most patients are unaware of AR and it's associated risks of respiratory complications, productivity loss, and poor health status. **(Nur Husna SM et al, 2022).** The rhinitis associated with AR has traditionally been classified as either seasonal (occurring during a specific season) or perennial (occurring throughout the year). There are, however, some patients who do not fit into this classification scheme. Thus, identifying the severity and duration of symptoms is essential for better managing AR patients. The AR and its Impact on Asthma (ARIA) guidelines classified AR into four types based on the duration (intermittent or persistent) and severity (mild, moderate and severe). **(DeShazo RD et al., 2020), (Akhouri S, 2013)**
India, which accounts for nearly 20% of the global population (approximately 1.35 billion people), has seen a notable rise in allergic diseases, including AR and asthma, over recent decades. It is estimated that 20–30% of the population experiences AR as a systemic condition rather than a localized nasal disorder **(Moitra S et al., 2023)**. Despite its widespread prevalence, AR is frequently underrecognized, affecting nearly 75% of children and 80% of individuals with asthma. Additionally, around 22% of adolescents in India are diagnosed with AR, though the true prevalence may be underestimated, particularly in rural and suburban areas, due to a lack of comprehensive epidemiological studies. Several environmental and genetic factors contribute to AR, with newly identified triggers such as proximity to waste disposal sites, vehicular pollution, and artificial nighttime lighting, all of which have been linked to increased AR

incidence (**Moitra S, 2023; Krishna MT**). Although a range of treatment options is available, AR management in India remains inadequate due to low awareness levels, widespread self-medication, and poor adherence to clinical guidelines (**Shah A et al., 2009; Moitra S et al., 2023**). Addressing these gaps through education, standardized treatment protocols, and improved healthcare accessibility is essential for better disease control and patient outcomes.The International Study of Asthma and Allergies in Childhood (ISAAC) assessed asthma and allergy prevalence across 14 centers in India, examining key determinants and trends in children. During Phase I of ISAAC (1998), nasal symptoms were reported in 12.5% of children aged 6–7 years and 18.6% of those aged 13–14 years. By Phase III (2009), the prevalence increased to 23.3% in the younger age group and 23.6% in adolescents, with cases of allergic rhino conjunctivitis rising to 3.9% and 10.4%, respectively (**Fok AO et al., 2009**). While AR is not a life-threatening condition, it can significantly impair daily functioning, reduce productivity, and negatively affect overall quality of life, leading to substantial socioeconomic consequences (**Camelo-Nunes IC et al., 2010**). Recognizing the need for better AR management, the Association of Otolaryngologists of India (AOI) introduced practical guidelines in 2022 to facilitate integrated care for AR patients. The primary goals of treatment include symptom relief, prevention of disease progression, and management of complications. Recommended therapies consist of oral and intranasal antihistamines, intranasal corticosteroids, leukotriene receptor antagonists, decongestants, and, in select cases, oral corticosteroids (**AOI, 2022**). Implementing these guidelines effectively could enhance treatment outcomes and improve the quality of life for AR patients in India. The primary goal of AR management is to achieve optimal symptom control to improve the quality of life. Despite the availability of pharmacotherapy and established guidelines, knowledge gaps persist among physicians, particularly in primary care settings, leading to inadequate treatment and poor symptom control (**Abdullah B, 2022**). Suboptimal management of AR can significantly impair daily activities at home, work, and school, exacerbating the socioeconomic burden of the disease. In India, AR remains frequently neglected and undertreated due to self-medication practices, limited awareness, and poor adherence to evidence-based guidelines (**Sinha B, 2015**). Addressing these concerns, the present study aims to assess the efficacy and safety of conventional pharmacotherapy options—including oral and oral/intranasal antihistamines (AHs, INAHs), intranasal corticosteroids (INCS), and immunotherapy (subcutaneous (SCIT) and sublingual (SLIT))—in alleviating AR symptoms. By evaluating real-world treatment outcomes, this study seeks to bridge existing gaps in pharmacotherapy use and provide evidence-based insights for optimizing AR management in clinical practice.

MATERIALS AND METHODS

Study Design

This was a 12-month, prospective, observational cohort study conducted at a tertiary care hospital in India. The study aimed to evaluate the efficacy and safety of pharmacotherapeutic agents used in the management of AR. Treatments were prescribed by physicians independently, and the researchers did not intervene in clinical decisions.

Participants

Inclusion Criteria:

Adults aged 18–65 years with a clinical diagnosis of AR (confirmed via skin prick tests or serum-specific IgE) and moderate-to-severe symptoms affecting daily activities or sleep. Participants had been prescribed at least one of the following therapies: AHs, INAHs, INCS, or SCIT, SLIT.

Exclusion Criteria:

Patients with uncontrolled asthma, nasal polyps, or recent systemic corticosteroid use; pregnant or breastfeeding individuals; or those unwilling to adhere to study follow-ups.

Sample size

The required sample size for this study was calculated using an online sample size calculator. Based on an 80% confidence level, a 5% margin of error, and an assumed population proportion of 50%, the minimum required sample size was 96 participants for a total population of 230. This ensures that the real value falls within ±5% of the measured value with the specified confidence level. To account for

potential dropouts and ensure adequate statistical power for subgroup analyses, a final sample size of 230 participants was selected.

Ethical Considerations

Confidentiality of patient data was ensured throughout the study, and all records were anonymized before analysis. The study followed the ethical principles outlined in the Declaration of Helsinki.

Data Collection and Documentation

This observational study focuses on data collection through clinical observations, patient-reported outcomes, and medical records, without intervention. The study involved baseline assessments at enrollment and follow-up evaluations every three months for a total duration of 12 months. Data collection focused on demographic characteristics, clinical history, treatment regimen, symptom severity, quality of life, medication adherence, adverse drug reactions (ADRs), and exacerbations.

Outcome Measures:

The primary outcomes assessed in this study include the reduction of symptoms, as measured by the Total Nasal Symptom Score (TNSS), and improvements in quality of life, evaluated using the Rhinoconjunctivitis Quality of Life Questionnaire (RQLQ). Additionally, secondary outcomes comprised a decrease in the utilization of rescue medication and the occurrence of adverse events (AEs).

Data Analysis:

The study employs both descriptive and inferential statistics to analyze data. For descriptive statistics, the mean ± standard deviation (SD) is calculated for continuous variables, while proportions (%) are used for categorical variables. Inferential statistics include an efficacy analysis utilizing repeated-measures ANOVA to assess changes in TNSS and RQLQ scores over time, with pairwise comparisons adjusted through Bonferroni correction for multiple comparisons. A safety analysis is also performed, comparing incidence rates of adverse events (AEs) using the Chi-square test or Fisher's exact test. The study conducts subgroup analysis through stratified analyses based on AR severity (mild, moderate, severe) and type (seasonal or perennial). Additionally, missing data will be handled through multiple imputation, under the assumption that the data are missing at random.

RESULTS

A total of 230 participants were included in the study. Table 1 presents the baseline demographic and clinical characteristics of the study population across the five treatment groups: AHs, INAHs, INCS, SCIT, and SLIT. The mean age of participants across all groups was comparable, ranging from 38.5 ± 11.8 years (INCS) to 39.4 ± 11.2 years (AHs), with no statistically significant difference between groups ($p = 0.92$). The gender distribution was balanced, with 50–54.3% of participants being male across all treatment groups ($p = 0.88$). In terms of AR classification, seasonal allergic rhinitis (SAR) was more prevalent, affecting 63.0–66.7% of participants, while perennial allergic rhinitis (PAR) accounted for 33.3–37.0% of cases. No significant difference was observed in AR subtype distribution across treatment groups ($p = 0.89$).Table 2 shows TNSS reduction across treatment groups over 12 months. At baseline, TNSS scores were similar across groups (7.3–7.5). By Month 3, all groups showed improvement, with INCS (4.0 ± 1.2) achieving the greatest reduction, followed by SCIT (4.3 ± 1.3) and SLIT (4.4 ± 1.4). Antihistamines (AHs, INAHs) provided moderate relief (5.3 ± 1.4, 5.1 ± 1.4). By Month 6, INCS (2.9 ± 1.1) continued to show the most significant improvement, with SCIT (3.1 ± 1.1) and SLIT (3.3 ± 1.2) also performing well. At 12 months, INCS achieved the most significant TNSS reduction (2.1 ± 1.0, 71% improvement), followed by SCIT (2.5 ± 0.9, 66%) and SLIT (2.7 ± 1.0, 63%). AHs and INAHs showed only moderate symptom relief (42–45%). All between-group differences were statistically significant ($p < 0.001$), confirming INCS and immunotherapy (SCIT, SLIT) as the most effective long-term treatments (Figure 1).Table 3 presents the RQLQ scores over 12 months across treatment groups. At baseline, scores ranged from 3.8 to 3.9 across all groups. By Month 3, all groups demonstrated improvement, with INCS showing the most significant reduction (2.2 ± 0.4), followed by SCIT (2.4 ± 0.6) and SLIT (2.6 ± 0.6). AHs and INAHs exhibited moderate improvements (3.0 ± 0.6 and 2.9 ± 0.6, respectively). At Month 6, INCS continued to show the greatest enhancement (1.8 ± 0.4), followed by SCIT (2.0 ± 0.4) and SLIT (2.2 ± 0.4). By 12 months, INCS achieved the greatest improvement in quality of life (1.5 ± 0.3, representing a 61% reduction), followed by SCIT (1.7 ± 0.3, 58%) and SLIT (1.8 ± 0.3, 53%). AHs (2.5

± 0.4) and INAHs (2.3 ± 0.4) showed lesser but notable improvements. All differences were statistically significant ($p < 0.001$), confirming INCS and immunotherapy (SCIT, SLIT) as the most effective treatments for enhancing quality of life.Table 4 presents adverse events across treatment groups. Mild systemic effects were most prevalent with AHs (13.0%), whereas INAHs (15.6%) and INCS (18.0%) exhibited higher rates of nasal irritation and bleeding ($p < 0.01$). Localised reactions were significantly more frequent with SCIT (25.4%) compared to SLIT (7.1%) ($p < 0.001$). Severe systemic reactions occurred in SCIT (3.5%) but were not observed in SLIT ($p = 0.01$). Overall, SCIT demonstrated the highest incidence of adverse events, whereas SLIT and INCS showed more favourable safety profiles.
A multiple linear regression model was used to identify factors influencing TNSS reduction at 12 months (Table 5). Treatment type was the strongest predictor, with INCS (-2.25, $p < 0.001$), SCIT (-1.80, $p < 0.001$), and SLIT (-1.60, $p < 0.001$) significantly associated with greater symptom improvement compared to AHs (reference group).Neither gender ($\beta = 0.15$, $p = 0.29$) nor AR type (seasonal vs. perennial, $\beta = -0.18$, $p = 0.17$) significantly influenced TNSS reduction. The model explained 62% of the variance (Adjusted $R^2 = 0.62$), highlighting the strong impact of INCS and immunotherapy on symptom control.

DISCUSSION

This study, conducted in South India, provides real-world evidence on the efficacy and safety of pharmacotherapeutic agents used in AR management. Among 230 participants, INCS demonstrated the highest symptom reduction 71% TNSS improvement and quality of life enhancement (61% RQLQ improvement), followed SCIT and SLIT. Antihistamines provided moderate symptom relief, with 42-45% TNSS improvement. Adverse events were minimal, with SCIT being associated with localized injection site reactions. These findings reinforce existing guidelines that INCS and immunotherapy remain the most effective AR treatments for long-term symptom control **(Bousquet et al., 2020; Moitra et al., 2023)**.Numerous international studies support our findings that INCS offer better symptom relief than antihistamines **(Yáñez A et a., 2002)**. Our results are in line with various global studies and meta-analyses that have demonstrated the greater effectiveness of INCS over AHs in managing AR symptoms (Nielsen LP, 2003). For example, Bousquet et al. (2008), in the ARIA (Allergic Rhinitis and its Impact on Asthma) guidelines, noted that INCS outperform AHs in alleviating nasal congestion, enhancing quality of life, and preventing flare-ups **(Bousquet et al. 2008)**. A meta-analysis by **Weiner et al. (1998)**, which involved over 2,000 patients, indicated that INCS led to a significant improvement in nasal symptom scores ($p < 0.001$) and increased overall patient satisfaction. Our findings are consistent with several Indian studies that have highlighted the superior efficacy of INCS. Nagpure PS et al., 2016, conducted a study in North India and found that INCS significantly reduced AR symptoms **(Nagpure PS et al., 2016)**. INCS have strong anti-inflammatory effects that target the causes of AR by decreasing mucosal inflammation, eosinophil infiltration, and cytokine release. Unlike AHs, which only provide symptomatic relief by blocking histamine receptors, INCS are more effective in alleviating nasal congestion due to their ability to reduce mucosal edema and vascular permeability **(Trangsrud AJ, 2002)**.Our results also indicate that INCS significantly improved QoL measures compared to AHs. This is consistent with **Brozek et al. (2017)**, in a systematic review, found that INCS were associated with greater improvements in sleep, productivity, and daily activities compared to AHs. Though India advanced in having AOI guidelines for the treatment of AR are available **(AOI 2022)**, currently, there are no guideline recommendations for the duration of INCS treatment for AR. Real-world AR-INCS prescription durations vary between countries and actual use tends to be shorter than prescribed. Understanding underlying factors may support appropriate AR-INCS use. **(Larenas-Linnemann, 2024)**AR is a significant yet often underdiagnosed and undertreated condition in India, despite affecting a large proportion of the population. A recent expert consensus in India, developed through the Delphi method, reinforces the need for early diagnosis, standardized treatment protocols, and improved adherence to evidence-based guidelines. However, barriers such as limited physician awareness, poor patient compliance, and underutilization of immunotherapy (SCIT, SLIT) persist, affecting optimal disease management. The consensus highlights the importance of enhancing clinician training, patient education, and cost-effective treatment strategies to improve AR care in India **(Narasimhan R, 2024)**. Our study aligns with these findings, emphasizing the urgent need for guideline implementation and healthcare policy improvements to ensure better long-

term disease control and patient outcomes.This research presents clinical data from South India, shedding light on local treatment practices and patient adherence behaviors. A 12-month longitudinal follow-up facilitates a thorough evaluation of immediate and extended treatment efficacy, essential for assessing chronic conditions like AR. Furthermore, the study utilized validated assessment tools, including the TNSS and RQLQ. By employing these standardized measures, the research enhances outcome measurement reliability and result comparability.These strengths are notable, but we must acknowledge limitations. As a single-centre study, results may not apply to other areas in India due to varying environmental and genetic factors affecting AR and treatment responses. The observational nature of this study limits our ability to establish causal links between treatments and outcomes; confounding factors like lifestyle, socio-economic conditions, and healthcare access may bias responses. The low immunotherapy uptake likely relates to accessibility and cost issues, potentially leading to an underestimation of its effectiveness in India. Future research should enhance the availability and affordability of immunotherapy for better long-term disease management. To strengthen evidence for AR treatment in India, multicenter randomized controlled trials (RCTs) across different regions are essential for improving the generalizability of findings.

CONCLUSION

In conclusion, our study reaffirms that INCS provide superior symptom relief in patients with AR, consistent with global evidence. These findings support the use of INCS as a first-line therapy for AR, particularly in moderate-to-severe cases, and highlight the need for patient education and adherence strategies to optimize treatment outcomes. Future research should explore the role of combination therapies and emerging treatments (e.g., biologics) in AR management.

REFERENCES

1. Abdullah B, Abdul Latiff AH, Manuel AM, et al. Pharmacological Management of Allergic Rhinitis: A Consensus Statement from the Malaysian Society of Allergy and Immunology. J Asthma Allergy. 2022;15:983-1003. Published 2022 Aug 2. doi:10.2147/JAA.S374346.
2. Akhouri S, House SA. Allergic rhinitis. InStatPearls [Internet] 2023 Jul 16. StatPearls Publishing.
3. Alnahas S, Abouammoh N, Althagafi W, Abd-Ellatif EE. Prevalence, severity, and risk factors of allergic rhinitis among schoolchildren in Saudi Arabia: A national cross-sectional study, 2019. World Allergy Organ J. 2023;16(10):100824. Published 2023 Oct 10. doi:10.1016/j.waojou.2023.100824.
4. Association of Otolaryngologists of India (AOI). AOI guidelines for allergic rhinitis management [Internet]. 2022 [cited 2024 Jan 29]. Available from: https://www.aoihns.in/wp-content/uploads/AOI-AR-Guidelines.pdf
5. Bousquet J, Anto JM, Bachert C, Baiardini I, Bosnic-Anticevich S, Walter Canonica G, Melén E, Palomares O, Scadding GK, Togias A, Toppila-Salmi S. Allergic rhinitis. Nature Reviews Disease Primers. 2020 Dec 3;6(1):95.
6. Bousquet J, Khaltaev N, Cruz AA, et al. Allergic Rhinitis and its Impact on Asthma (ARIA) 2008 update (in collaboration with the World Health Organization, GA(2)LEN and AllerGen). Allergy. 2008;63 Suppl 86:8-160. doi:10.1111/j.1398-9995.2007.01620.x
7. Brożek JL, Bousquet J, Agache I, Agarwal A, Bachert C, Bosnic-Anticevich S, Brignardello-Petersen R, Canonica GW, Casale T, Chavannes NH, De Sousa JC. Allergic Rhinitis and its Impact on Asthma (ARIA) guidelines—2016 revision. Journal of Allergy and Clinical Immunology. 2017 Oct 1;140(4):950-8.
8. Camelo-Nunes IC, Solé D. Allergic rhinitis: indicators of quality of life. J Bras Pneumol. 2010;36(1):124-133. doi:10.1590/s1806-37132010000100017
9. DeShazo RD, Kemp SF. Patient education: Allergic rhinitis (Beyond the Basics). Topic. 2020 Nov;370:1-2.
10. Fok AO, Wong GW. What have we learnt from ISAAC phase III in the Asia-Pacific rim?. Curr Opin Allergy Clin Immunol. 2009;9(2):116-122. doi:10.1097/aci.0b013e3283292256.
11. Krishna MT, Mahesh PA, Vedanthan P, Moitra S, Mehta V, Christopher DJ. An appraisal of allergic disorders in India and an urgent call for action. World Allergy Organization Journal. 2020 Jul 1;13(7):100446.
12. Larenas-Linnemann, D.E., Domthong, P., Di Francesco, R.C., González-Pérez, R. and Verma, M., 2024. General practitioner and patient perspectives on intranasal corticosteroids for allergic rhinitis: Treatment duration and obstacles to adherence, findings from a recent survey. World Allergy Organization Journal, 17(7), p.100925.
13. Moitra S, Mahesh PA, Moitra S. Allergic rhinitis in India. Clin Exp Allergy. 2023;53(7):765-776. doi:10.1111/cea.14295
14. Moitra S, Mahesh PA, Moitra S. Allergic rhinitis in India. Clin Exp Allergy. 2023;53(7):765-776. doi:10.1111/cea.14295
15. Narasimhan R, Roy S, Koralla M, Thomas PK, Ilambarathi M, Balamurugan S, Harish M, Ravichandar S, Medikeri G, Bose P, Rajasekar MK. Expert Panel Consensus Recommendations for Allergic Rhinitis in Patients with Asthma in India. Pulmonary Therapy. 2024 Oct 17:1-27.
16. Nagpure PS, Yadav MK, Chavan S, Manpe S, Ganeshkar R. Effectiveness of Oral Antihistamines and Intranasal Steroid Spray in relieving Ocular Symptoms in Allergic Rhinitis using Total Ocular Symptom Score. An International Journal of Otorhinolaryngology Clinics. 2016 Dec 1;8(2):45-50.

17. Nielsen LP, Dahl R. Comparison of intranasal corticosteroids and antihistamines in allergic rhinitis: a review of randomized, controlled trials. Am J Respir Med. 2003;2(1):55-65. doi:10.1007/BF03256639
18. Nur Husna SM, Tan HT, Md Shukri N, Mohd Ashari NS, Wong KK. Allergic Rhinitis: A Clinical and Pathophysiological Overview. Front Med (Lausanne). 2022;9:874114. Published 2022 Apr 7. doi:10.3389/fmed.2022.874114.
19. Shah A, Pawankar R. Allergic rhinitis and co-morbid asthma: perspective from India ~ ARIA Asia-Pacific Workshop report. Asian Pac J Allergy Immunol. 2009;27(1):71-77.
20. Sinha B; Vibha, Singla R, Chowdhury R. Allergic Rhinitis: A neglected disease - A community based assessment among adults in Delhi. J Postgrad Med. 2015;61(3):169-175. doi:10.4103/0022-3859.159418.
21. Trangsrud AJ, Whitaker AL, Small RE. Intranasal corticosteroids for allergic rhinitis. Pharmacotherapy. 2002;22(11):1458-1467. doi:10.1592/phco.22.16.1458.33692
22. Togias AG. Systemic immunologic and inflammatory aspects of allergic rhinitis. J Allergy Clin Immunol. 2000;106(5 Suppl):S247-S250. doi:10.1067/mai.2000.110157
23. Yáñez A, Rodrigo GJ. Intranasal corticosteroids versus topical H1 receptor antagonists for the treatment of allergic rhinitis: a systematic review with meta-analysis. Ann Allergy Asthma Immunol. 2002;89(5):479-484. doi:10.1016/S1081-1206(10)62085-6
24. Weiner JM, Abramson MJ, Puy RM. Intranasal corticosteroids versus oral H1 receptor antagonists in allergic rhinitis: systematic review of randomised controlled trials. BMJ. 1998;317(7173):1624-1629. doi:10.1136/bmj.317.7173.1624
25. Wheatley LM, Togias A. Allergic rhinitis. New England Journal of Medicine. 2015 Jan 29;372(5):456-63.
26. Worldwide variations in the prevalence of asthma symptoms: the International Study of Asthma and Allergies in Childhood (ISAAC). Eur Respir J. 1998;12(2):315-335. doi:10.1183/09031936.98.12020315.

TABLES AND FIGURES

Table 1: Baseline Characteristics of Participants

Variable	AH (n = 46)	INAH (n = 45)	INCS (n = 46)	SCIT (n = 46)	SLIT (n = 47)	p-value
Mean Age (years)	39.4 ± 11.2	38.7 ± 12.0	38.5 ± 11.8	39.1 ± 11.6	38.9 ± 11.9	0.92
Gender (Male, %)	54.3%	51.1%	50.0%	52.2%	53.2%	0.88
Seasonal AR (%)	63.0%	66.7%	65.2%	63.0%	64.4%	0.89
Perennial AR (%)	37.0%	33.3%	34.8%	37.0%	35.6%	0.89
Baseline TNSS	7.4 ± 1.5	7.3 ± 1.4	7.5 ± 1.4	7.4 ± 1.3	7.3 ± 1.6	0.91
Baseline RQLQ Score	3.8 ± 0.7	3.9 ± 0.8	3.8 ± 0.7	3.8 ± 0.8	3.9 ± 0.8	0.85

Total Nasal Symptom Score (TNSS), Rhinoconjunctivitis Quality of Life Questionnaire (RQLQ).

Table 2: Mean TNSS Reduction Over 12 Months

Timepoint	AH (n = 46)	INAH (n = 45)	INCS (n = 46)	SCIT (n = 46)	SLIT (n = 47)	p-value
Baseline	7.4 ± 1.5	7.3 ± 1.4	7.5 ± 1.4	7.4 ± 1.3	7.3 ± 1.6	—
3 Months	5.3 ± 1.4	5.1 ± 1.4	4.0 ± 1.2	4.3 ± 1.3	4.4 ± 1.4	<0.001 **
6 Months	4.7 ± 1.3	4.2 ± 1.2	2.9 ± 1.1	3.1 ± 1.1	3.3 ± 1.2	<0.001 **
12 Months	4.3 ± 1.2	4.0 ± 1.1	2.1 ± 1.0	2.5 ± 0.9	2.7 ± 1.0	<0.001 **

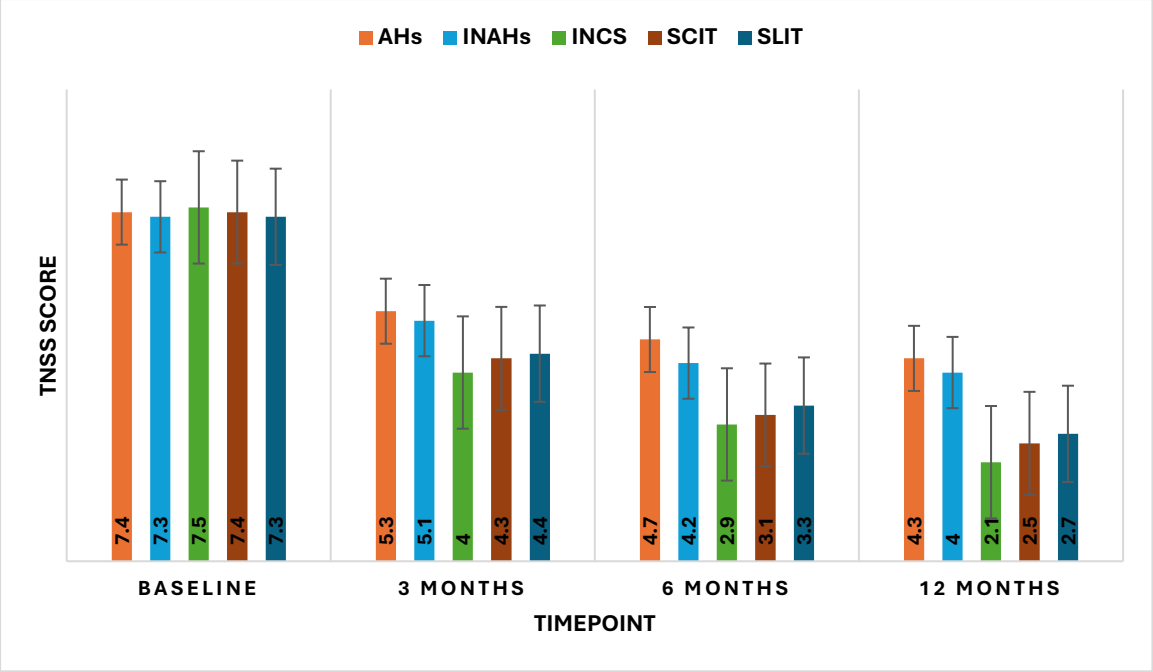

Figure 1: TNSS Reduction Over Time by Treatment Group

In the evaluation of treatment options, INCS showed the most significant TNSS reduction, with a 71% improvement after 12 months. Both SCIT and SLIT demonstrated comparable long-term benefits, exhibiting TNSS reductions of 66% and 63%, respectively. On the other hand, AHs and INAHs provided moderate symptom relief, achieving TNSS reductions of 42% and 45%, respectively.

Table 3: Mean RQLQ Improvement Over 12 Months

Timepoint	AH (n = 46)	INAH (n = 45)	INCS (n = 46)	SCIT (n = 46)	SLIT (n = 47)	p-value
Baseline	3.8 ± 0.7	3.9 ± 0.8	3.8 ± 0.7	3.8 ± 0.8	3.9 ± 0.8	–
3 Months	3.0 ± 0.6	2.9 ± 0.6	2.2 ± 0.5	2.4 ± 0.6	2.6 ± 0.6	<0.001 **
6 Months	2.7 ± 0.5	2.4 ± 0.5	1.8 ± 0.4	2.0 ± 0.4	2.2 ± 0.4	<0.001 **
12 Months	2.5 ± 0.4	2.3 ± 0.4	1.5 ± 0.3	1.7 ± 0.3	1.8 ± 0.3	<0.001 **

Table 4: Adverse Event Incidence

Adverse Event	AH	INAH	INCS	SCIT	SLIT	p-value
Mild systemic effects	13.0	11.1%	9.0%	8.7%	7.0%	0.04 *
Nasal irritation/bleeding	–	15.6%	18.0%	–	–	<0.01 **
Localized injection reactions	–	–	–	25.4%	7.1%	<0.001 **
Severe systemic reactions	–	–	–	3.5%	0%	0.01 *

Table 5 Regression Analysis: Predicting TNSS Reduction

Variable	Coefficient (β)	Standard Error	t-value	p-value	95% CI
Intercept	0.52	0.34	1.53	0.13	[-0.15, 1.19]
INCS (ref: AHs)	-2.25	0.21	-10.71	<0.001 **	[-2.67, -1.83]
SCIT (ref: AHs)	-1.80	0.22	-8.18	<0.001 **	[-2.24, -1.36]

SLIT (ref: AHs)	-1.60	0.23	-6.96	<0.001 **	[-2.05, -1.15]
Gender (Male = 1)	0.15	0.14	1.07	0.29	[-0.12, 0.42]
AR Type (Seasonal = 1)	-0.18	0.13	-1.38	0.17	[-0.44, 0.08]

Adjusted R^2: 0.62.