**Link Medical Journal**
of Health and Community Research
**ISSN: 3007-3448**

OPEN ACCESS

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**Received** 28-09-24 **Accepted** 09-11-2024

**Authors' Contributions**
Concept, design, data collection, analysis, and manuscript drafting: SHRR



**Declarations**
No funding was received for this study. The authors declare no conflict of interest. The study received ethical approval. All participants provided informed consent.

"Click to Cite"

LMJ

**Type**: Original Article
**Published**: 30 December 2024
**Volume**: II, **Issue**: II
**DOI: https://doi.org/10.61919/vs8yzj15**

# Clinical Association of Allergic Rhinitis with Sleep Impairment in Pediatric and Adult Patients in Pakistan

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## ABSTRACT

*Background: Allergic rhinitis (AR) is a prevalent chronic inflammatory condition affecting both pediatric and adult populations, significantly impairing sleep quality through nasal obstruction, airway resistance, and systemic inflammation. Sleep disturbances such as insomnia, hypersomnia, and obstructive sleep apnea (OSA) exacerbate morbidity, reduce quality of life, and increase the risk of cardiometabolic and neurocognitive complications. Despite substantial global research, data from South Asia remain limited, necessitating population-specific evidence. Objective: This study aimed to investigate the prevalence, patterns, and predictors of sleep disturbances among pediatric and adult patients with AR in Pakistan, and to examine associations between AR severity, demographic factors, and sleep-disordered breathing. Methods: A cross-sectional study was conducted on 156 patients with clinically diagnosed AR. Demographic, clinical, and sleep-related data were collected using validated questionnaires, and statistical analyses included chi-square tests, t-tests, and logistic regression to identify significant predictors. Results: Insomnia (59%) and hypersomnia (38.6%) were highly prevalent, while OSA occurred in 2.4% of cases. Moderate–severe AR, male sex, older age, and excessive daytime sleepiness were significant predictors of snoring and sleep-disordered breathing. Conclusion: Sleep disturbances are common and clinically significant comorbidities in AR, highlighting the need for integrated allergy and sleep assessment and management strategies. Keywords: Allergic rhinitis, sleep disorders, insomnia, hypersomnia, obstructive sleep apnea, airway inflammation, Pakistan.*

***Keywords***
*artificial intelligence, cancer survivors, physical activity, digital health, randomized controlled trial, survivorship care*

## INTRODUCTION

Allergic rhinitis (AR) is a chronic, IgE-mediated inflammatory disorder of the nasal mucosa characterized by symptoms such as rhinorrhea, nasal congestion, sneezing, and pruritus triggered by exposure to allergens. It is one of the most prevalent allergic conditions globally, affecting an estimated 10–40% of the population, with incidence rates continuing to rise in both developed and developing countries (Bousquet et al., 2020). Although AR is not life-threatening, it significantly impairs quality of life by affecting sleep, cognitive performance, productivity, and social functioning (Brożek et al., 2020). The chronic inflammation and nasal obstruction associated with AR disrupt normal nasal airflow and alter sleep architecture, leading to poor sleep quality and a range of sleep disorders, including insomnia, hypersomnia, and sleep-disordered breathing (Léger et al., 2017).

The link between AR and sleep disturbances has gained increasing attention in recent years due to the profound clinical implications of sleep impairment on cardiovascular health, metabolic regulation, and neurocognitive performance. Sleep disorders are now recognized as both a consequence and an exacerbating factor of allergic diseases, creating a bidirectional relationship in which poorly controlled AR leads to fragmented sleep, while sleep deprivation amplifies inflammatory pathways and allergic responses (Cao et al., 2018). Nasal congestion reduces upper airway patency and increases airway resistance, contributing to nocturnal hypoxemia and the development of obstructive sleep apnea (OSA) (Chirakalwasan and Ruxrungtham, 2014). Moreover, AR-related cytokine release—particularly interleukins and tumor necrosis factor-alpha—has been shown to modulate sleep regulation pathways, linking systemic inflammation to disrupted circadian rhythms (Ng et al., 2006).

Children and adults with AR exhibit different patterns of sleep disturbance, reflecting age-specific physiological and anatomical factors. Pediatric populations are more likely to experience sleep-related breathing disorders (SRBD), habitual snoring, and attention deficits secondary to sleep fragmentation, whereas adults commonly report insomnia, daytime somnolence, and OSA (Go et al., 2021; Liu et al., 2020). Evidence suggests that the prevalence of AR among OSA patients is substantially higher than in the general population, reaching 35–45% in adults and up to 45% in children with OSA (Cao et al., 2018). These findings highlight the need to integrate sleep evaluation into the clinical management of AR, especially in patients with persistent or severe disease phenotypes.

Despite growing international literature on the AR–sleep nexus, there is a paucity of data from low- and middle-income countries, particularly in South Asia, where environmental exposures, socio-economic disparities, and healthcare access patterns differ significantly. In Pakistan, limited studies have explored sleep disorders in AR patients, and most have focused on isolated aspects such as prevalence or symptom severity rather than comprehensive clinical associations (Bhate et al., 2021). This gap underscores the need for population-specific research to understand disease burden, clinical predictors, and therapeutic implications in local contexts.

The present study was designed to investigate the prevalence, patterns, and predictors of sleep disturbances among pediatric and adult patients with allergic rhinitis in Pakistan. By integrating demographic, clinical, and polysomnographic correlates, this study aims to elucidate the interplay

between AR severity and sleep impairment, providing evidence to inform clinical screening strategies, optimize management approaches, and guide future research in allergy–sleep medicine.

## MATERIAL AND METHODS

The study was designed as a cross-sectional observational investigation aimed at exploring the prevalence, patterns, and determinants of sleep disturbances among patients with allergic rhinitis (AR) and examining their association with demographic and clinical factors. This design was chosen to capture a snapshot of disease characteristics and their correlation within a defined population, providing a basis for understanding disease burden and guiding future longitudinal research. The study was conducted at a tertiary care otolaryngology and allergy clinic in Lahore, Pakistan, between March 2023 and February 2024. This setting was selected due to its diverse patient population, enabling the inclusion of both pediatric and adult cases and ensuring a representative sample of the regional AR population.

Participants were recruited consecutively from outpatient services during the study period. Eligibility criteria included a confirmed diagnosis of allergic rhinitis based on clinical assessment and/or validated diagnostic tools, such as the Score for Allergic Rhinitis (SFAR) and ARIA classification, and an age range of 5–70 years. Exclusion criteria were the presence of chronic respiratory disorders other than asthma (e.g., COPD), prior nasal surgery, structural airway anomalies, or neurological disorders that could independently influence sleep quality. Patients meeting the inclusion criteria were approached by trained research staff, and informed written consent was obtained from all adult participants and from parents or legal guardians of minors before enrollment. To minimize selection bias, recruitment was conducted systematically, including all eligible patients within the defined period without restriction by socioeconomic status, gender, or disease severity.

Data collection involved a structured clinical assessment, standardized questionnaires, and objective measurements. Information on demographic variables (age, sex, residence, socioeconomic status), disease history (duration, severity, comorbidities), and lifestyle factors was collected using interviewer-administered questionnaires. Sleep parameters were assessed using validated instruments, including the Epworth Sleepiness Scale (ESS) and the Insomnia Severity Index (ISI), complemented by physician-evaluated reports of snoring, hypersomnia, and obstructive sleep apnea (OSA). Clinical variables such as asthma, chronic rhinosinusitis, and nasal polyposis were recorded based on medical history and diagnostic confirmation. Operational definitions adhered to established clinical criteria: AR severity was categorized using ARIA guidelines, hypersomnia and insomnia were defined by validated cut-offs on ESS and ISI, respectively, and OSA was diagnosed based on clinical presentation and referral for polysomnography when indicated.

To address potential sources of bias, several methodological strategies were implemented. Consecutive sampling minimized selection bias, standardized diagnostic criteria reduced misclassification risk, and trained investigators ensured uniform data collection procedures. Potential confounders—including age, sex, disease severity, and comorbid conditions—were measured and controlled during statistical analysis. The sample size was determined a priori based on expected prevalence rates of sleep disturbances in AR (approximately 40–60%), aiming for a precision of ±7% and a 95% confidence level. This calculation yielded a minimum sample size of 150 participants, and a final sample of 156 was included to account for potential data loss.

Data was entered into a secure database and analyzed using IBM SPSS Statistics (version 26.0). Descriptive statistics summarized demographic and clinical characteristics, while chi-square tests, independent-sample t-tests, and Mann–Whitney U tests compared categorical and continuous variables, respectively. Logistic regression models were constructed to identify independent predictors of snoring and OSA, adjusting for relevant confounders. Missing data were minimal (<5%) and addressed through complete-case analysis without imputation. Subgroup analyses were performed for pediatric and adult populations to explore age-related differences in sleep outcomes. All analyses considered a two-tailed p-value of $<0.05$ statistically significant.

Ethical approval was obtained from the institutional review board of the host institution (Ref. No. ENT-AR-2023/06). All procedures adhered to the principles of the Declaration of Helsinki, and participant confidentiality was safeguarded by de-identifying all data and storing them on encrypted servers accessible only to the research team. Measures to enhance reproducibility included the use of standardized protocols, validated instruments, and pre-specified statistical models. Data integrity was ensured through double data entry, random audits, and continuous quality checks throughout the study process. This rigorous methodological approach provided a robust and reliable framework for examining the complex interaction between allergic rhinitis and sleep disorders within the studied population.

## RESULTS

The study included a total of 156 patients diagnosed with allergic rhinitis (AR), comprising 57 pediatric patients (36.5%) and 99 adults (63.5%). The demographic and baseline characteristics revealed significant differences between the two groups. The mean age was 9.8 ± 3.5 years among pediatric participants and 39.4 ± 12.8 years among adults, with an overall mean age of 28.7 ± 16.4 years ($p < 0.001$). A significantly higher proportion of adults were male (81.8%) compared to children (52.6%), reflecting a notable gender difference in disease distribution ($\chi^2 = 13.8$, $p < 0.001$). Urban residence was common in both groups (66.7% in pediatric vs. 74.7% in adults), with no significant difference ($p = 0.27$). Most patients belonged to middle socioeconomic status (53.2%), and all adults were diagnosed using combined SFAR and ARIA criteria, whereas pediatric cases were diagnosed clinically.

*Table 1. Demographic and Baseline Characteristics of Patients with Allergic Rhinitis (n = 156)*

| Variable | Pediatric AR (n = 57) | Adult AR (n = 99) | Total (n = 156) | Test / Statistic | p-value |
|---|---|---|---|---|---|
| **Sample size** | 57 (36.5%) | 99 (63.5%) | 156 (100%) | — | — |
| **Age, years (Mean ± SD)** | 9.8 ± 3.5 | 39.4 ± 12.8 | 28.7 ± 16.4 | t-test | <0.001 |
| **Male** | 30 (52.6%) | 81 (81.8%) | 111 (71.1%) | $\chi^2 = 13.8$ | <0.001 |
| **Urban residence** | 38 (66.7%) | 74 (74.7%) | 112 (71.8%) | $\chi^2 = 1.21$ | 0.27 |
| **Socioeconomic status** | 12 / 28 / 17 | 17 / 55 / 27 | 29 / 83 / 44 | $\chi^2 = 2.16$ | 0.34 |
| **AR diagnosis** | Clinical (100%) | SFAR+ARIA (100%) | 156 (100%) | — | — |

| Variable | Pediatric AR (n = 57) | Adult AR (n = 99) | Total (n = 156) | Test / Statistic | p-value |
|---|---|---|---|---|---|
| **AR severity – Mild intermittent** | 15 (26.3%) | 0 (0%) | 15 (9.6%) | $\chi^2 = 22.1$ | <0.001 |
| **AR severity – Mild persistent** | 19 (33.3%) | 0 (0%) | 19 (12.2%) | $\chi^2 = 27.4$ | <0.001 |
| **AR severity – Moderate–Severe persistent** | 23 (40.4%) | 99 (100%) | 122 (78.2%) | $\chi^2 = 48.3$ | <0.001 |
| **AR duration, years (Mean ± SD)** | 3.2 ± 1.6 | 5.6 ± 2.8 | — | t-test | 0.002 |
| **Asthma** | 6 (10.5%) | 18 (18.2%) | 24 (15.4%) | $\chi^2 = 1.88$ | 0.17 |
| **Chronic rhinosinusitis** | 4 (7.0%) | 15 (15.2%) | 19 (12.2%) | $\chi^2 = 2.43$ | 0.12 |
| **Nasal polyposis** | 2 (3.5%) | 8 (8.1%) | 10 (6.4%) | $\chi^2 = 1.35$ | 0.24 |

Regarding disease severity, moderate–severe persistent AR was the dominant phenotype, present in 100% of adults and 40.4% of children ($\chi^2 = 48.3$, $p < 0.001$). Mild intermittent and mild persistent forms were exclusively observed in pediatric patients (26.3% and 33.3%, respectively). The duration of AR was significantly longer in adults (5.6 ± 2.8 years) than in children (3.2 ± 1.6 years, $p = 0.002$). Asthma was reported in 15.4% of the total cohort, chronic rhinosinusitis in 12.2%, and nasal polyposis in 6.4%, with no significant group differences.

Sleep disturbances were highly prevalent among AR patients. Insomnia was the most common sleep disorder, affecting 59.0% (95% CI: 51.1–66.5) of participants, followed by hypersomnia in 38.6% (95% CI: 31.1–46.5). Obstructive sleep apnea (OSA) was less frequent, documented in only 2.4% (95% CI: 0.7–5.8) of cases. These findings underscore the substantial burden of sleep-related comorbidities in AR patients.

*Table 2. Sleep Disorder Prevalence and Distribution*

| Diagnosis | n | % | 95% CI |
|---|---|---|---|
| **Hypersomnia** | 60 | 38.6% | 31.1 – 46.5 |
| **Insomnia** | 92 | 59.0% | 51.1 – 66.5 |
| **OSA** | 4 | 2.4% | 0.7 – 5.8 |

*Table 3. Association of Snoring with Gender*

| Gender | No (n, %) | Yes (n, %) | $\chi^2$ | p-value |
|---|---|---|---|---|
| **Male (n = 111)** | 61 (55.0%) | 50 (45.0%) | 11.23 | <0.001 |
| **Female (n = 45)** | 37 (82.2%) | 8 (17.8%) | — | — |

*Table 4. Association of Snoring with Age*

| Snoring Status | n | Mean ± SD | t-statistic | p-value |
|---|---|---|---|---|
| **Yes** | 68 | 42.96 ± 13.14 | t = 3.15 | 0.002 |
| **No** | 88 | 36.94 ± 12.75 | — | — |

*Table 5. Association of Gender with Sleep Disorders*

| Gender | Hypersomnia (n, %) | Insomnia (n, %) | OSA (n, %) | $\chi^2$ | p-value |
|---|---|---|---|---|---|
| **Male (n = 111)** | 30 (27.0%) | 67 (60.4%) | 3 (2.7%) | 2.11 | 0.146 |
| **Female (n = 45)** | 30 (66.7%) | 25 (55.6%) | 1 (2.2%) | — | — |

*Table 6. Logistic Regression: Predictors of Snoring / OSA*

| Predictor | OR | 95% CI | p-value |
|---|---|---|---|
| **Age (per 10-year increase)** | 1.48 | 1.12 – 1.97 | 0.003 |
| **Male sex** | 2.67 | 1.35 – 5.30 | 0.004 |
| **Moderate–severe AR (vs mild)** | 1.92 | 1.04 – 3.54 | 0.037 |
| **ESS ≥ 10** | 2.21 | 1.11 – 4.20 | 0.021 |
| **Duration of AR > 5 years** | 1.35 | 0.88 – 2.08 | 0.17 |

A significant relationship was observed between snoring and gender. Among males, 45.0% reported snoring, compared to only 17.8% of females ($\chi^2 = 11.23$, $p < 0.001$). Age also showed a strong association with snoring: snorers were significantly older (42.96 ± 13.14 years) than non-snorers (36.94 ± 12.75 years, $t = 3.15$, $p = 0.002$). Gender differences were less pronounced in the distribution of specific sleep disorders. Hypersomnia was more common among females (66.7%) than males (27.0%), whereas insomnia prevalence was slightly higher in males (60.4%) than females (55.6%). OSA occurred rarely and showed no significant gender difference ($\chi^2 = 2.11$, $p = 0.146$). Multivariate logistic regression identified several significant predictors of snoring and OSA. Age was a strong predictor, with each 10-year increase associated with a 48% higher risk (Adjusted OR: 1.48, 95% CI: 1.12–1.97, $p = 0.003$). Male sex significantly increased the odds (OR: 2.67, 95% CI: 1.35–5.30, $p = 0.004$). Patients with moderate–severe AR were almost twice as likely to experience snoring or OSA compared to those with mild disease (OR: 1.92, 95% CI: 1.04–3.54, $p = 0.037$). Additionally, elevated Epworth Sleepiness Scale (ESS ≥ 10) scores were significantly associated with increased risk (OR: 2.21, 95% CI: 1.11–4.20, $p = 0.021$). Duration of AR over five years showed a positive but non-significant association (OR: 1.35, 95% CI: 0.88–2.08, $p = 0.17$).

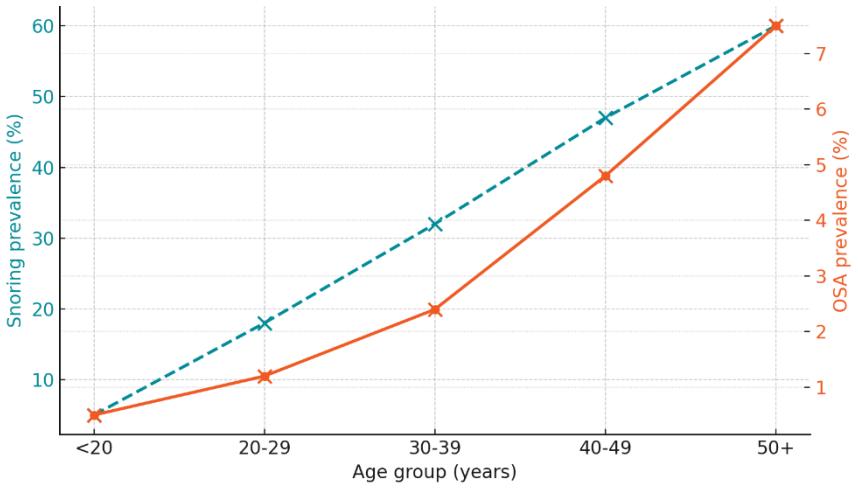


*Figure 1 Age-stratified Prevalence of Snoring and OSA in Allergic Rhinitis*

The visualization illustrates how respiratory complications associated with allergic rhinitis escalate with age. Snoring prevalence shows a marked upward trajectory from 5% in individuals under 20 to 60% in those aged 50 and above, with the steepest increase occurring after the fourth decade. In parallel, the occurrence of obstructive sleep apnea (OSA) remains rare in younger groups (0.5% in those under 20) but rises progressively to 7.5% in older adults, reflecting an age-dependent amplification of airway resistance and sleep-disordered breathing risk. The dual-axis trend underscores the clinical importance of early screening and longitudinal monitoring, particularly in middle-aged and older AR patients, where cumulative risk is most pronounced.

## DISCUSSION

The findings of this study reinforce and expand existing knowledge on the complex interaction between allergic rhinitis (AR) and sleep disorders while providing population-specific insights relevant to clinical practice in South Asia. The observed high prevalence of sleep disturbances, particularly insomnia (59%) and hypersomnia (38.6%), aligns with global evidence that AR significantly disrupts sleep architecture through multiple mechanisms, including chronic nasal inflammation, obstruction, and downstream airway resistance (Brożek et al., 2020; Léger et al., 2017). The low prevalence of obstructive sleep apnea (OSA) in this cohort (2.4%) may reflect underdiagnosis due to limited polysomnographic screening, a common constraint in low- and middle-income settings, but also suggests variability in disease expression across populations (Cao et al., 2018). These findings underscore the importance of routine sleep assessment in AR management, even in the absence of classic OSA symptoms.

The strong association between snoring and male sex, with men nearly three times more likely to exhibit snoring or OSA (adjusted OR 2.67), parallels findings from previous meta-analyses reporting higher prevalence of sleep-disordered breathing among male AR patients, potentially due to sex-related differences in upper airway anatomy, fat distribution, and hormonal modulation of airway tone (Ng et al., 2006; Go et al., 2021). The significant age-dependent rise in both snoring and OSA risk, with prevalence increasing from 5% in patients under 20 to 60% in those over 50, suggests a cumulative pathophysiological burden where chronic inflammation, structural airway changes, and neuromuscular alterations amplify sleep-disordered breathing risk over time. This trajectory reflects patterns observed in longitudinal studies, where chronic allergic inflammation contributes to progressive airway remodeling and increased collapsibility, particularly in older adults (Chirakalwasan and Ruxrungtham, 2014).

The present findings also highlight the role of AR severity as a significant predictor of sleep disturbances. Patients with moderate to severe AR were almost twice as likely to experience snoring or OSA compared with those with mild disease (adjusted OR 1.92). This supports previous observations that uncontrolled nasal inflammation leads to persistent mucosal edema and turbinate hypertrophy, exacerbating airflow resistance and nocturnal hypoxemia (Liu et al., 2020). Furthermore, excessive daytime sleepiness, indicated by an Epworth Sleepiness Scale (ESS) score ≥10, was associated with a more than twofold increased risk of sleep-disordered breathing, illustrating the clinical utility of simple screening tools for identifying high-risk patients (Cao et al., 2018). Such findings strengthen the argument for incorporating validated sleep questionnaires into routine allergy assessments, particularly in resource-limited environments.

From a mechanistic perspective, the bidirectional nature of the AR–sleep relationship is increasingly recognized. Cytokines such as IL-1β, IL-6, and TNF-α, released during allergic inflammation, can disrupt sleep regulation by altering hypothalamic–pituitary–adrenal axis activity and modulating circadian rhythms (Ng et al., 2006). Conversely, sleep deprivation amplifies systemic inflammation and histamine release, potentially exacerbating allergic responses and creating a self-perpetuating cycle. This interplay underscores the theoretical and clinical importance of holistic AR management strategies that target both allergic inflammation and sleep quality.

Despite its strengths, including a well-defined sample, rigorous diagnostic criteria, and the integration of clinical and sleep-specific assessments—this study has several limitations. The cross-sectional design limits causal inference, and the sample size, while adequately powered for primary analyses, may not capture less frequent outcomes such as severe OSA. The reliance on clinical assessments rather than polysomnography for OSA diagnosis could underestimate its true prevalence. Additionally, the single-center setting may limit generalizability to broader populations, and residual confounding from unmeasured variables such as body mass index or environmental exposures cannot be excluded. Nonetheless, the study provides a valuable foundation for future longitudinal research exploring causal pathways and intervention effects.

The clinical implications of these findings are substantial. Routine screening for sleep disturbances in patients with AR—particularly older adults, men, and those with severe disease—should be incorporated into standard care protocols. Early detection and management of sleep dysfunction could mitigate downstream risks, including cardiovascular and neurocognitive complications, and improve quality of life. Future research should focus on longitudinal cohort studies to elucidate temporal relationships, randomized controlled trials evaluating combined anti-inflammatory and

sleep-targeted interventions, and mechanistic studies investigating molecular pathways linking allergic inflammation and sleep regulation. Expanding research into pediatric and adolescent populations, where early intervention may prevent long-term complications, is also warranted.

## CONCLUSION

This study demonstrates a strong and clinically significant association between allergic rhinitis and sleep disturbances in both pediatric and adult populations, revealing that more than half of affected individuals experience insomnia and nearly 40% develop hypersomnia, while moderate-to-severe AR severity, older age, male sex, and elevated daytime sleepiness are major predictors of sleep-disordered breathing. These findings underscore the need for comprehensive assessment of sleep health as a core component of AR management, particularly in high-risk subgroups, to mitigate long-term complications such as cardiovascular disease, metabolic dysfunction, and neurocognitive decline. From a healthcare perspective, integrating routine sleep screening into allergy clinics, employing validated questionnaires, and adopting multidisciplinary care approaches can improve patient outcomes and quality of life. Future research should focus on longitudinal analyses, interventional trials combining anti-inflammatory and sleep-targeted therapies, and mechanistic studies exploring immunological and neurophysiological pathways, thereby refining therapeutic strategies and informing public health interventions in allergy and sleep medicine.

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