Section: Pulmonology

Original Research Article

CROSS-SECTIONAL STUDY OF ALLERGEN SENSITIZATION TO COMMON BENGALURU POLLENS AND ASTHMA SEVERITY IN ADULTS

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ABSTRACT

Background: Aeroallergen sensitization contributes significantly to asthma morbidity, and regional pollen profiles influence sensitization patterns. Bengaluru's unique climate, vegetation diversity, and rapid urban growth have led to notable pollen exposure, warranting localized epidemiological assessment. The aim is to assess the prevalence and pattern of sensitization to common Bengaluru pollens and its association with asthma severity among adults.

Materials and Methods: A hospital-based cross-sectional study was conducted among 140 clinically diagnosed adult asthma patients. Skin prick testing (SPT) was performed using standardized extracts of region-relevant pollens. Asthma severity was graded using GINA criteria. Data were analyzed using descriptive statistics, one-sample tests, chi-square test, and risk estimates; $p < 0.05$ was considered statistically significant.

Results: The mean age was 38.6 ± 11.9 years with female predominance (55.7%). Overall pollen sensitization prevalence was 65.7%; Parthenium (45.7%), Prosopis (37.1%), and Amaranthus (33.6%) were the leading sensitizers. Polysensitization was noted in 45.0% of participants. A significant association was found between sensitization and severity; moderate–severe asthma was observed in 57.6% of sensitized individuals compared to 31.3% among non-sensitized ($p = 0.002$). Polysensitization significantly predominated among moderate and severe persistent asthma categories ($p = 0.014$).

Conclusion: Allergen sensitization, especially polysensitization to regional pollens, is highly prevalent and strongly correlated with higher asthma severity in adults in Bengaluru. Incorporation of routine allergen testing and region-adapted preventive strategies may improve asthma outcomes.

Keywords: Pollen sensitization, Asthma severity, Skin prick test (SPT).

INTRODUCTION

Asthma is a chronic inflammatory airway disorder characterized by variable airflow limitation, bronchial hyperresponsiveness, and recurrent episodes of wheeze, dyspnea, chest tightness, and cough, often showing diurnal variation. The prevalence of asthma has been rising globally, particularly in rapidly urbanizing settings where environmental, lifestyle, and genetic factors interact to influence disease manifestation and severity.[1] Allergic sensitization plays a pivotal role in the pathophysiology of asthma, and exposure to aeroallergens such as pollens, fungal spores, and house dust mites has been strongly associated with airway inflammation, reduced lung function, and poor asthma control. Pollen allergens are known triggers of type I hypersensitivity reactions mediated by IgE; sensitized individuals develop exaggerated airway responses upon inhalation of specific pollen particles, leading to worsening asthma symptoms and exacerbations. Bengaluru, located in southern India, possesses a distinct subtropical climate, diverse vegetation, and prolonged flowering seasons, making it a hotspot for airborne pollen dispersion. Rapid landscaping, uncontrolled growth of allergenic exotic species like Parthenium hysterophorus, and increased tree plantation in urban areas have contributed to

rising pollen loads, particularly from species such as Prosopis juliflora, Casuarina equisetifolia, Amaranthus sp., and Cocos nucifera. With increased air pollution levels caused by vehicular traffic, biomass burning, and construction dust, pollen grains may also undergo morphological changes, increasing their allergenicity and ability to penetrate deeper airways.[2,3]

Several aeroallergen sensitization studies from different geographical locations indicate that region-specific pollen exposure must be studied for accurate diagnosis and treatment planning. Bengaluru-specific studies have demonstrated seasonal peaks, especially during pre-monsoon and post-monsoon periods, with evidence of polysensitization patterns among chronic respiratory patients. However, there is a relative paucity of updated data correlating sensitization to common local pollens with asthma severity among adults. Understanding this correlation is essential for allergen avoidance counseling, immunotherapy decision-making, and public health interventions. Skin prick testing (SPT) and serum allergen-specific IgE estimation represent the most widely accepted diagnostic approaches for assessing sensitization. Identifying sensitization patterns in adult asthma patients can also help differentiate between atopic and non-atopic asthma, predict exacerbation susceptibility, and guide tailored treatment strategies such as biological therapy.[4,5]

Aim: To assess the prevalence of allergen sensitization to common Bengaluru pollens and its association with asthma severity among adults.

Objectives

1. To determine the prevalence and pattern of sensitization to selected common pollens among adult asthma patients using skin prick testing.
2. To classify participants into asthma severity categories based on standardized clinical criteria.
3. To analyze the correlation between pollen sensitization profiles and asthma severity grades.

MATERIALS AND METHODS

Source of Data: Data was obtained from adult asthma patients attending the outpatient and inpatient departments of the Pulmonology and Allergy Clinic of a tertiary care hospital in Bengaluru.

Study Design: A hospital-based cross-sectional observational study.

Study Location: Department of Pulmonology and Immuno-Allergy, tertiary care teaching hospital in Bengaluru, Karnataka.

Study Duration: Twelve months, including recruitment, testing and data analysis phases.

Sample Size: A total of 140 adult patients diagnosed with asthma were enrolled.

Inclusion Criteria

- Adults aged 18–60 years with confirmed clinical asthma as per GINA guidelines.
- Stable asthma without acute exacerbation within the previous 4 weeks.
- Individuals willing to undergo skin prick testing and provide informed consent.

Exclusion Criteria:

- Pregnant or lactating women.
- Patients with dermatological conditions unsuitable for SPT (eczema, dermographism).
- Patients on oral antihistamines, beta-blockers, or immunosuppressants within the last 7 days.
- History of anaphylaxis or uncontrolled comorbid illness.

Procedure and Methodology: Eligible participants were clinically evaluated and classified into severity categories using GINA criteria based on symptom frequency, nocturnal symptoms, rescue medication use, and spirometry. Standardized allergen extracts of common Bengaluru pollens (e.g., Parthenium, Prosopis, Casuarina, Amaranthus, Cocos nucifera) were used to perform SPT on the volar forearm using sterile lancets. Histamine (10 mg/mL) and saline were used as positive and negative controls respectively. Wheal size was measured after 15–20 minutes, and a wheal ≥3 mm greater than the negative control was considered positive. Sensitization patterns were recorded as monosensitization or polysensitization.

Sample Processing: All SPT allergen reagents were stored and handled under manufacturer-specified refrigerated conditions. Wheals were traced, measured using calipers, photographed, and documented.

Data Collection: Demographic details, symptom profile, medicine history, spirometry values, and questionnaire-based environmental exposure history were recorded using a structured proforma.

Statistical Methods: Data was analyzed using SPSS software. Categorical variables were summarized using frequency and percentages; continuous variables using mean ± SD. Association between sensitization and asthma severity was tested using Chi-Square or Fisher's exact test. Logistic regression was used to identify independent predictors; $p<0.05$ was considered statistically significant.

RESULTS

[Table 1] outlines the baseline characteristics of the 140 adult asthma patients included in the study, along with the overall prevalence of pollen sensitization and its crude association with asthma severity. The mean age of participants was 38.6 ± 11.9 years, which did not differ significantly from the reference value of 40 years ($p = 0.17$), indicating a typical adult asthma demographic. Females constituted a slightly higher proportion of the sample (55.7%), though this distribution was not statistically different from an expected 50% ($p = 0.17$). The average duration of asthma was 7.8 ± 4.3 years, which was significantly higher than the reference of 7 years ($p = 0.03$), suggesting that most participants had longstanding disease. Sensitization to at least one pollen allergen on skin prick testing was observed in 65.7% of

patients, a prevalence significantly higher than 50% ($p < 0.001$), highlighting the predominance of atopy in this population. When asthma severity was compared across sensitization status, 57.6% of sensitized individuals had moderate-to-severe asthma compared to only 31.3% of non-sensitized individuals. The risk difference of 26.4% (95% CI: 9.8% to 42.9%) and the significant chi-square value ($\chi^2 = 9.74$, $p = 0.002$).

Table 1: Baseline characteristics and overall prevalence of pollen sensitization and its crude association with asthma severity (N = 140)

Measure	Category / Comparison	n (%) or Mean ± SD	Effect & test of significance	95% CI	p-value
Age (years)	–	38.6 ± 11.9	One-sample t vs 40 years: t = −1.39, df = 139	Mean: 36.6 to 40.6 years	0.17
Sex	Female	78 (55.7%)	One-sample z vs 50% female: z = 1.36	47.5% to 63.9%	0.17
	Male	62 (44.3%)	–	–	–
Duration of asthma (years)	–	7.8 ± 4.3	One-sample t vs 7 years: t = 2.20, df = 139	Mean: 7.1 to 8.5 years	0.03
Any pollen sensitization (SPT)	Present	92 (65.7%)	One-sample z vs 50%: z = 3.92	57.9% to 73.6%	<0.001
	Absent	48 (34.3%)	–	–	–
Moderate–severe asthma (GINA)*	Sensitized (n = 92): 53 moderate–severe / 39 mild	53/92 (57.6%)	Risk diff (sens vs non-sens) = 26.4%; $\chi^2 = 9.74$, df = 1	RD: 9.8% to 42.9%	0.002
	Non-sensitized (n = 48): 15 moderate–severe / 33 mild	15/48 (31.3%)	–	–	–

*Moderate–severe asthma = GINA moderate persistent + severe persistent categories.

Table 2: Prevalence and pattern of sensitization to common Bengaluru pollens using skin prick testing (N = 140)

Measure	Category / Comparison	n (%)	Effect & test of significance	95% CI for proportion	p-value
Parthenium sensitization	SPT positive	64 (45.7%)	One-sample z vs 30%: z = 3.73	37.5% to 54.0%	<0.001
	SPT negative	76 (54.3%)	–	–	–
Prosopis sensitization	SPT positive	52 (37.1%)	One-sample z vs 30%: z = 1.75	29.1% to 45.1%	0.08
	SPT negative	88 (62.9%)	–	–	–
Casuarina sensitization	SPT positive	39 (27.9%)	One-sample z vs 30%: z = −0.57	20.4% to 35.3%	0.57
	SPT negative	101 (72.1%)	–	–	–
Amaranthus sensitization	SPT positive	47 (33.6%)	One-sample z vs 30%: z = 0.89	25.7% to 41.4%	0.37
	SPT negative	93 (66.4%)	–	–	–
Cocos nucifera sensitization	SPT positive	31 (22.1%)	One-sample z vs 30%: z = −2.24	15.3% to 29.0%	0.03
	SPT negative	109 (77.9%)	–	–	–
Pattern of sensitization	No sensitization	48 (34.3%)	χ^2 goodness-of-fit vs equal 33.3% each: $\chi^2 = 12.44$, df = 2	26.4% to 42.1%	0.002
	Monosensitization (1 pollen)	29 (20.7%)	–	14.0% to 27.4%	–
	Polysensitization (≥2 pollens)	63 (45.0%)	–	36.8% to 53.2%	–

[Table 2] presents the prevalence and pattern of sensitization to major Bengaluru pollens as determined by skin prick testing. Among the tested allergens, Parthenium hysterophorus showed the highest sensitization rate at 45.7%, significantly exceeding the expected prevalence of 30% ($p < 0.001$). Sensitization to Prosopis juliflora was observed in 37.1% of participants, a higher but statistically non-significant difference from 30% ($p = 0.08$). Casuarina sensitization was present in 27.9% of participants, showing no meaningful deviation from expected values ($p = 0.57$). Similarly, Amaranthus pollen sensitization occurred in 33.6% of the sample, which did not significantly differ from 30% ($p = 0.37$). Sensitization to Cocos nucifera pollen was lower at 22.1% and was significantly less than the 30% reference value ($p = 0.03$). Evaluating overall sensitization patterns, 34.3% of patients were non-sensitized, 20.7% exhibited monosensitization, and notably, 45.0% demonstrated polysensitization. A goodness-of-fit analysis revealed that the distribution of sensitization patterns differed significantly from an equal expected distribution ($\chi^2 = 12.44$, $p = 0.002$).

Table 3: Classification of participants into asthma severity categories based on standardized clinical criteria (N = 140)

Measure	Category / Comparison	n (%)	Effect & test of significance	95% CI for proportion	p-value
Asthma severity (GINA category)	Mild intermittent	33 (23.6%)	χ^2 goodness-of-fit vs equal 25% each: $\chi^2 = 1.14$, df = 3	16.5% to 30.6%	0.77
	Mild persistent	39 (27.9%)	–	20.4% to 35.3%	–
	Moderate persistent	37 (26.4%)	–	19.1% to 33.7%	–
	Severe persistent	31 (22.1%)	–	15.3% to 29.0%	–
FEV_1 % predicted (overall)	–	71.3 ± 14.8	One-sample t vs 70% predicted: t = 1.04, df = 139	Mean: 68.8% to 73.8% predicted	0.30

[Table 3] summarises the distribution of asthma severity based on GINA criteria and the mean FEV_1% predicted among the study participants. The distribution of asthma severity categories showed 23.6% with mild intermittent asthma, 27.9% with mild persistent, 26.4% with moderate persistent, and 22.1% with severe persistent asthma. A chi-square goodness-of-fit test indicated no significant deviation from an equal distribution across the four categories (p = 0.77), reflecting an even spread of disease severity in the sample. The overall mean FEV_1 was 71.3 ± 14.8% predicted, which did not significantly differ from the reference value of 70% (p = 0.30), suggesting moderate airflow limitation on average.

Table 4: Correlation between pollen sensitization profile and asthma severity grades (N = 140)

Asthma severity (GINA)	Sensitization profile	n (%) within severity category
Mild intermittent (n=33)	Non-sensitized	18 (54.5%)
	Monosensitized	8 (24.2%)
	Polysensitized	7 (21.2%)
Mild persistent (n=39)	Non-sensitized	15 (38.5%)
	Monosensitized	9 (23.1%)
	Polysensitized	15 (38.5%)
Moderate persistent (n=37)	Non-sensitized	9 (24.3%)
	Monosensitized	6 (16.2%)
	Polysensitized	22 (59.5%)
Severe persistent (n=31)	Non-sensitized	6 (19.4%)
	Monosensitized	6 (19.4%)
	Polysensitized	19 (61.3%)

χ^2 test of independence (4×3): $\chi^2 = 16.0$, df = 6; p=0.014

[Table 4] evaluates the correlation between pollen sensitization profiles and asthma severity. In the mild intermittent group, non-sensitized individuals were predominant (54.5%), whereas polysensitized individuals formed the smallest proportion (21.2%). In the mild persistent group, non-sensitized and polysensitized individuals appeared in equal measure (38.5% each), with monosensitization accounting for the remainder. A clear shift became evident in the moderate persistent group, where polysensitization was the dominant pattern (59.5%), while non-sensitized individuals were relatively fewer (24.3%). This trend intensified in the severe persistent category, where 61.3% of patients were polysensitized and only 19.4% were non-sensitized. The chi-square test of independence revealed a statistically significant association between sensitization profile and asthma severity ($\chi^2 = 16.0$, p = 0.014), demonstrating that patients with more severe asthma were far more likely to be polysensitized to multiple pollens.

DISCUSSION

The most striking finding in [Table 1] is the high prevalence of any pollen sensitization (65.7%), which is significantly higher than the 50% reference value. This aligns with several Indian SPT studies in nasobronchial allergy, where 60–80% of symptomatic patients react to at least one aeroallergen on SPT. Reddy KB et al (2021),[6] reported that 82.3% of patients with allergic airway disease had positive SPT to ≥1 aeroallergen, with dust mites predominating but relevant pollen reactivity also present. Kuravi N et al (2021),[7] from a tertiary allergy centre similarly documented high SPT positivity in IgE-mediated respiratory allergy. Our observation that sensitized patients had a substantially higher proportion of moderate–severe asthma (57.6%) compared to non-sensitized patients (31.3%), with a risk difference of 26.4% and statistically significant χ^2, is consistent with the broader evidence that aeroallergen sensitization is a key risk factor for more severe asthma phenotypes. Moitra S et al (2023),[8] showed that sensitization to aeroallergens, particularly multiple allergens, was associated with lower lung function and greater disease severity. Narasimhan R et al (2025),[9] also demonstrated that sensitized adults had poorer asthma control and higher severity scores than non-sensitized individuals, closely mirroring our crude association between sensitization and GINA-defined severity.

[Table 2] highlights the detailed pattern of sensitization to common Bengaluru pollens. Parthenium emerged as the most frequent pollen sensitizer (45.7%), significantly exceeding the 30% reference, while Prosopis (37.1%), Amaranthus (33.6%) and Casuarina (27.9%) showed intermediate prevalence, and Cocos nucifera had a comparatively lower rate (22.1%). These findings are in line with regional aerobiological and clinical data that identify Parthenium hysterophorus, Prosopis juliflora and Amaranthus species as important outdoor allergens in many parts of India. A review of Indian data notes that Parthenium, Amaranthus and Prosopis together account for a significant proportion of pollen allergy, with Bengaluru specifically reporting notable contributions from these pollens to respiratory allergy burden. Barne M et al (2022),[10] found grass and weed pollens among the common aeroallergens sensitizing patients in a coastal South Indian city, while Gowda G et al (2025),[11] emphasized the growing role of pollen, in addition to mites and molds, as major triggers of allergic rhinitis and asthma in India's urban environments. The exact rank order of specific pollens naturally varies by local flora, but the prominence of Parthenium in our study is consistent with earlier Bangalore-based SPT surveys and epidemiologic work identifying it as a major invasive allergenic weed.

An important feature of our cohort is the predominance of polysensitization: 45.0% of patients were sensitized to two or more pollens, compared with 20.7% with monosensitization and 34.3% with no pollen sensitization. The distribution differed significantly from an equal three-way split, indicating that multi-pollen sensitization is the rule rather than the exception. This pattern corresponds well with Indian and international literature showing high rates of polysensitization among patients with allergic airway disease. Shikha G et al (2022),[1] noted that most SPT-positive patients reacted to multiple aeroallergens (mites, pollens, molds), and Krishna MT et al (2020),[5] similarly reported widespread polysensitization among their cohort. At a broader level, Jayakrishnan VY et al (2024),[2] demonstrated that allergic polysensitization clusters are strongly enriched among patients with more severe asthma and suggested that polysensitization should be considered a key marker in asthma phenotyping.

[Table 3] shows that our sample had a fairly even distribution across GINA severity categories—about one-quarter each in mild intermittent, mild persistent, moderate persistent and severe persistent groups—with no statistically significant deviation from an equal distribution. The overall mean FEV_1 was around 71% predicted, consistent with a mix of mild to moderately severe obstruction. This pattern is compatible with other hospital-based studies that recruit across the severity spectrum. Pr B et al (2023),[12] reported a similar spread of asthma severity among outpatients, where roughly half to two-thirds of patients fell into the persistent asthma categories. These distributions also align with GINA-based evaluations of adult asthma cohorts where, in real-world practice, moderate disease often predominates.

The most clinically relevant observation emerges in [Table 4], which demonstrates a clear gradient between sensitization profile and asthma severity. Non-sensitized patients dominate in the mild intermittent group (54.5%), whereas polysensitized patients become increasingly common as severity rises, accounting for 59.5% of moderate persistent and 61.3% of severe persistent cases. The overall χ^2 test confirms a significant association between sensitization pattern and GINA severity class ($p = 0.014$). This trend is in strong agreement with several contemporary studies. The RADIANT asthma study from Kerala showed that patients sensitized to multiple aeroallergens had more severe airflow limitation and higher exacerbation rates than those with limited or no sensitization. Jain S et al (2022),[13] reported that aeroallergen sensitization, especially to multiple allergens, was independently associated with more severe asthma. Laha A et al (2023),[14] also found that moderate–severe asthma was more frequent in polysensitized patients than in mono- or non-sensitized individuals. At an international level, Monisha R et al (2023),[15] & Pandey AK et al (2025),[16] demonstrated that polysensitization clusters were strongly associated with severe asthma phenotypes and worse clinical outcomes. Together, these external data support our finding that multi-pollen sensitization is not just a biochemical or skin test phenomenon but translates into clinically more severe disease.

CONCLUSION

The present cross-sectional study demonstrated a high prevalence (65.7%) of allergen sensitization to common Bengaluru pollens among adults with asthma, with Parthenium, Prosopis, and Amaranthus emerging as key sensitizing agents. Nearly half of the sensitized individuals exhibited polysensitization patterns, indicating wide allergen exposure and possible shared aeroallergenic pathways in this urban setting. Sensitization status showed a clear association with asthma severity, where polysensitized patients predominantly belonged to moderate and severe persistent asthma categories, suggesting that multi-allergen sensitization may serve as a clinically relevant predictor of more severe disease. These findings highlight the importance of routine aeroallergen testing, region-specific allergen profiling, targeted immunotherapy planning, and public health strategies focused on environmental allergen control, particularly weed management and urban landscaping policies in Bengaluru.

Limitations

1. Cross-sectional nature restricted causal inference between sensitization and disease severity, preventing establishment of temporality.

2. Hospital-based sample may not fully represent the general community, leading to selection bias toward symptomatic individuals.
3. Use of skin prick test only without serum-specific IgE or component-resolved diagnostics may have limited molecular characterization of sensitization.
4. No assessment of seasonal variations, flowering cycles, or real-time airborne pollen quantification, which may influence positivity and severity patterns.
5. Environmental and occupational exposure variables such as pollution levels, housing conditions, and occupational allergens were not quantitatively analyzed.
6. Therapeutic and medication confounders, including inhaled corticosteroid dose and adherence, were not adjusted in severity correlation models.

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