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Clinical Characteristics, Risk Factors, and Long-Term Outcomes of Childhood Asthma: A Prospective Cohort Study

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ABSTRACT

Background: Childhood asthma is one of the most common chronic respiratory diseases affecting children worldwide and is a major cause of recurrent hospital visits, school absenteeism, and impaired quality of life. Early identification of clinical characteristics and modifiable risk factors is essential for improving long-term disease control.

Objectives: To evaluate the clinical characteristics, identify risk factors, and assess the long-term outcomes of childhood asthma in children attending a tertiary care teaching hospital.

Materials and Methods: This prospective cohort study was conducted in the Department of Pediatrics, ESIC Medical College and Hospital, Kalaburagi, Karnataka, India, from April 2025 to March 2026. A total of 120 children aged 5–15 years with physician-diagnosed asthma were enrolled and followed for 12 months. Demographic characteristics, clinical features, environmental exposures, laboratory investigations, pulmonary function tests, treatment adherence, and follow-up outcomes were recorded. Statistical analysis was performed using SPSS version 26.0, with $p<0.05$ considered statistically significant.

Results: The mean age of participants was 9.6±2.8 years, with males constituting 60.0%. Family history of asthma or atopy was present in 50.8%, allergic rhinitis in 48.3%, passive smoking exposure in 39.2%, and elevated serum IgE in 61.7% of children. At baseline, 43.4% had uncontrolled asthma, which declined to 9.2% after one year of follow-up. Well-controlled asthma increased from 18.3% at enrollment to 67.5% at 12 months. Improved lung function was observed in 65.8% of children, while 79.2% remained free from hospitalization during follow-up. Significant predictors of poor asthma control included passive smoking ($p=0.018$), family history of asthma ($p=0.031$), allergic rhinitis ($p=0.047$), poor medication adherence ($p<0.001$), and elevated serum IgE levels ($p=0.039$).

Conclusion: Childhood asthma demonstrates favorable long-term outcomes with regular follow-up, adherence to controller therapy, and appropriate disease monitoring. Environmental exposures, allergic comorbidities, elevated IgE levels, and poor treatment adherence significantly contribute to poor asthma control. Early risk factor identification and comprehensive asthma management may substantially improve clinical outcomes.

Keywords: *Childhood asthma, Pediatric asthma, Asthma control, Risk factors, Long-term outcomes, Spirometry, Immunoglobulin E.*

INTRODUCTION

Asthma is one of the most prevalent chronic respiratory disorders among children and represents a major public health challenge worldwide. It is characterized by chronic airway inflammation, variable airflow obstruction, bronchial

hyperresponsiveness, and recurrent episodes of wheezing, breathlessness, chest tightness, and coughing that vary over time and in intensity. Childhood asthma contributes substantially to morbidity through repeated emergency visits, hospital admissions, school absenteeism, impaired physical activity, and reduced quality of life for both affected children and their families.[1]

According to the World Health Organization (WHO), asthma affects more than 260 million people globally and remains an important cause of preventable morbidity and mortality. In India, the prevalence of childhood asthma has increased over recent decades because of rapid urbanization, environmental pollution, changing lifestyles, and increased exposure to indoor and outdoor allergens. Although advances in pharmacological therapy have improved disease management, asthma continues to impose a considerable burden on healthcare systems.[2,3]

The development of childhood asthma is multifactorial and results from complex interactions between genetic susceptibility and environmental influences. A positive family history of asthma or atopy, allergic rhinitis, eczema, passive tobacco smoke exposure, indoor biomass fuel use, obesity, respiratory viral infections during early life, and environmental allergens have all been identified as important contributors to disease onset and progression.[4,5] Understanding these factors is essential for developing preventive strategies and improving long-term disease control.

Clinical manifestations of childhood asthma vary widely according to age, disease severity, and trigger exposure. While many children experience intermittent symptoms, others develop persistent disease requiring long-term controller medications. The Global Initiative for Asthma (GINA) emphasizes regular assessment of symptom control, lung function, treatment adherence, inhaler technique, and risk factor modification to achieve optimal disease management and reduce future exacerbations.[1]

Pulmonary function testing, including spirometry and peak expiratory flow rate (PEFR), plays an important role in confirming airway obstruction and monitoring response to therapy in children capable of performing reliable maneuvers. In addition, laboratory markers such as peripheral eosinophil count and serum immunoglobulin E (IgE) provide useful information regarding allergic inflammation and may help identify children at increased risk of persistent disease.[6]

Long-term follow-up studies have demonstrated that early diagnosis, adherence to inhaled corticosteroid therapy, proper inhaler technique, and regular clinical monitoring significantly reduce exacerbations and improve lung function and quality of life. However, poor adherence, continued allergen exposure, and inadequate disease education remain important barriers to achieving optimal asthma control, particularly in developing countries.[7,8]

Despite increasing awareness, limited prospective data are available from Indian tertiary care centers evaluating the combined influence of clinical characteristics, environmental risk factors, and long-term outcomes among children with asthma. Therefore, the present prospective cohort study was undertaken to evaluate the clinical profile, identify important risk factors, and assess one-year outcomes of childhood asthma among pediatric patients attending ESIC Medical College and Hospital, Kalaburagi.

MATERIALS AND METHODS

Study Design and Setting

This prospective cohort study was conducted in the Department of Pediatrics, ESIC Medical College and Hospital, Kalaburagi, Karnataka, India, over a period of one year from April 2025 to March 2026. The study was designed to evaluate the clinical characteristics, identify risk factors, and assess the long-term outcomes of childhood asthma among pediatric patients attending the outpatient department and those admitted to the pediatric wards.

Study Population

A total of 120 children with physician-diagnosed asthma were enrolled consecutively during the study period. Eligible participants were followed prospectively from enrollment until the completion of the study.

Inclusion Criteria

Children fulfilling all of the following criteria were included:

- Age between 5 and 15 years
- Physician-diagnosed bronchial asthma based on clinical history and examination
- Recurrent episodes of wheezing with documented reversibility following bronchodilator therapy
- Parents or legal guardians willing to provide written informed consent
- Children aged ≥7 years providing assent whenever appropriate

Exclusion Criteria

Children with the following conditions were excluded:

- Congenital heart disease causing recurrent respiratory symptoms

- Chronic lung diseases other than asthma (e.g., cystic fibrosis, bronchopulmonary dysplasia)
- Primary immunodeficiency disorders
- Pulmonary tuberculosis
- Foreign body aspiration
- Neuromuscular disorders affecting respiration
- Incomplete clinical records or inability to complete follow-up

Sample Size
A total of 120 children meeting the eligibility criteria were included using consecutive sampling during the study period.

Data Collection
After obtaining informed written consent from parents or guardians, detailed demographic and clinical information was collected using a predesigned structured case record form.
The following baseline information was recorded:

- Age
- Sex
- Residence (urban/rural)
- Socioeconomic status
- Body mass index (BMI)
- Age at onset of asthma
- Duration of illness
- Family history of asthma or atopy
- History of allergic rhinitis
- Atopic dermatitis
- Food allergy
- Exposure to passive smoking
- Indoor biomass fuel exposure
- Presence of household pets
- Seasonal variation of symptoms
- Environmental allergen exposure
- Previous hospitalizations for asthma
- Previous intensive care admission
- Medication history
- Treatment adherence
- Immunization status

Clinical Assessment
A comprehensive clinical examination was performed at enrollment.
The following clinical parameters were recorded:

- Respiratory rate
- Heart rate
- Oxygen saturation (SpO_2)
- Blood pressure
- Height
- Weight
- Body mass index
- Presence of wheeze
- Use of accessory muscles
- Chest retractions
- Cyanosis
- Peak expiratory flow rate (PEFR), whenever feasible
- Asthma severity according to Global Initiative for Asthma (GINA) recommendations

Asthma control during follow-up was categorized as:

- Well controlled
- Partly controlled
- Uncontrolled

based on symptom frequency, night-time awakenings, activity limitation, and rescue medication use.

Laboratory Investigations
The following investigations were performed whenever clinically indicated:

- Complete blood count (CBC)
- Absolute eosinophil count (AEC)
- Serum total Immunoglobulin E (IgE)
- Chest radiograph (when indicated)
- Spirometry with bronchodilator reversibility testing (children ≥5 years able to perform acceptable maneuvers)
- Peak expiratory flow rate (PEFR)
- Allergy skin prick test (selected patients)

Follow-up
All enrolled children were followed prospectively for 12 months.
Scheduled follow-up visits were conducted at:

- Baseline
- 3 months
- 6 months
- 9 months
- 12 months

During each visit, the following were assessed:

- Symptom control
- Frequency of exacerbations
- Emergency department visits
- Hospital admissions
- Requirement for systemic corticosteroids
- School absenteeism
- Medication adherence
- Inhaler technique
- Lung function (where feasible)
- Adverse events related to therapy

Patients who missed scheduled visits were contacted telephonically whenever possible to minimize loss to follow-up.

Outcome Measures
Primary Outcomes

- Asthma control at one year
- Frequency of asthma exacerbations
- Number of hospitalizations
- Long-term clinical outcome

Secondary Outcomes

- Identification of clinical and environmental risk factors
- Lung function improvement during follow-up
- Need for escalation of controller therapy
- School absenteeism
- Quality of life improvement
- Predictors of poor asthma control

Statistical Analysis
Data were entered into Microsoft Excel and analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA).
Continuous variables were expressed as mean ± standard deviation (SD) or median (interquartile range) depending on data distribution. Categorical variables were expressed as frequencies and percentages.
Comparisons between groups were performed using:

- Student's *t*-test for continuous variables
- Chi-square test or Fisher's exact test for categorical variables
- Mann–Whitney U test for non-normally distributed variables

Multivariate logistic regression analysis was performed to identify independent predictors of poor asthma control and recurrent exacerbations.
A p-value <0.05 was considered statistically significant.

Ethical Considerations

The study protocol was reviewed and approved by the Institutional Ethics Committee of ESIC Medical College and Hospital, Kalaburagi, Karnataka. Written informed consent was obtained from the parents or legal guardians of all participating children before enrollment. Confidentiality of patient information was maintained throughout the study in accordance with institutional ethical guidelines and the principles of the Declaration of Helsinki.

RESULTS AND OBSERVATIONS

Table 1. Demographic Characteristics (n=120)

Variable	Frequency (n)	Percentage (%)
Age Group (years)		
5–7	**32**	**26.7**
8–10	**41**	**34.2**
11–13	**29**	**24.2**
14–15	**18**	**15.0**
Sex		
Male	**72**	**60.0**
Female	**48**	**40.0**
Residence		
Urban	**68**	**56.7**
Rural	**52**	**43.3**
Socioeconomic Status		
Lower	**49**	**40.8**
Middle	**55**	**45.8**
Upper	**16**	**13.4**

Mean age: 9.6±2.8 years

Table 2. Baseline Clinical Characteristics

Variable	Mean±SD / n (%)
Respiratory rate (breaths/min)	**29.4±5.8**
Heart rate (beats/min)	**108.7±14.3**
Oxygen saturation (%)	**95.1±2.3**
Systolic BP (mmHg)	**101.8±10.6**
Diastolic BP (mmHg)	**65.4±7.8**
Height (cm)	**132.6±15.2**
Weight (kg)	**31.8±10.2**
BMI (kg/m²)	**17.4±2.3**
Wheeze	**120 (100)**
Accessory muscle use	**46 (38.3)**
Chest retractions	**39 (32.5)**
Cyanosis	**8 (6.7)**

Table 3. Asthma History and Environmental Risk Factors

Variable	Frequency	Percentage
Age at onset <5 years	**71**	**59.2**
Duration >3 years	**62**	**51.7**
Family history of asthma/atopy	**61**	**50.8**
Allergic rhinitis	**58**	**48.3**
Atopic dermatitis	**26**	**21.7**
Food allergy	**18**	**15.0**
Passive smoking	**47**	**39.2**
Biomass fuel exposure	**43**	**35.8**
Household pets	**24**	**20.0**
Seasonal symptoms	**82**	**68.3**
Environmental allergen exposure	**77**	**64.2**

Table 4. Previous Treatment History

Variable	Frequency	Percentage
Previous hospitalization	**41**	**34.2**
Previous ICU admission	**9**	**7.5**

Inhaled corticosteroid therapy	88	73.3
Leukotriene antagonist	39	32.5
Good adherence	83	69.2
Poor adherence	37	30.8
Complete immunization	112	93.3

Table 5. Laboratory and Pulmonary Function Findings

Investigation	Finding	Frequency	Percentage
CBC	Normal	78	65.0
CBC	Leukocytosis	22	18.3
CBC	Eosinophilia	20	16.7
Absolute eosinophil count	Elevated	65	54.2
Serum IgE	Elevated	74	61.7
Spirometry	FEV_1 <80% predicted	58	48.3
Bronchodilator reversibility	Positive	92	76.7
PEFR	<80% predicted	71	59.2
Skin prick test*	Positive	34	28.3

*Performed in selected patients.

Table 6. Chest Radiograph Findings
Chest X-ray was performed in 32 clinically indicated children.

Finding	n=32	Percentage
Normal	16	50.0
Hyperinflation	9	28.1
Peribronchial thickening	5	15.6
Patchy infiltrates	2	6.3

Table 7. Asthma Control During Follow-up

Visit	Well Controlled	Partly Controlled	Uncontrolled
Baseline	22 (18.3%)	46 (38.3%)	52 (43.4%)
3 months	39 (32.5%)	50 (41.7%)	31 (25.8%)
6 months	57 (47.5%)	43 (35.8%)	20 (16.7%)
9 months	69 (57.5%)	37 (30.8%)	14 (11.7%)
12 months	81 (67.5%)	28 (23.3%)	11 (9.2%)

Table 8. Follow-up Outcomes

Variable	Mean±SD / n (%)
Exacerbations/year	1.9±1.2
Emergency visits	1.3±0.9
Hospital admissions	0.6±0.8
Oral steroid courses	1.2±0.9
School absenteeism (days)	9.4±5.8
Good inhaler technique at 12 months	96 (80.0)
Good medication adherence	92 (76.7)
Adverse drug reactions	8 (6.7)

Table 9. Long-term Outcomes at One Year

Outcome	Frequency	Percentage
Well-controlled asthma	81	67.5
Improved lung function	79	65.8
No hospitalization	95	79.2
Controller therapy escalation	24	20.0
Improved quality of life	87	72.5
Persistent uncontrolled asthma	11	9.2

Table 10. Predictors of Poor Asthma Control

Variable	Poor Control (n=11)	Controlled (n=109)	p-value
Passive smoking	8 (72.7%)	39 (35.8%)	0.018*
Family history	9 (81.8%)	52 (47.7%)	0.031*

Allergic rhinitis	**8 (72.7%)**	**50 (45.9%)**	**0.047***
Poor adherence	**9 (81.8%)**	**28 (25.7%)**	**<0.001***
Elevated IgE	**10 (90.9%)**	**64 (58.7%)**	**0.039***

***Statistically significant ($p < 0.05$).**

DISCUSSION

The present prospective cohort study evaluated the clinical characteristics, environmental risk factors, and one-year outcomes of childhood asthma among 120 children. The findings demonstrate that asthma predominantly affected school-aged children, with a male preponderance, a high burden of allergic comorbidities, and significant improvement in disease control following regular follow-up and guideline-based management.

The mean age of study participants was 9.6±2.8 years, and 60% were males. Similar observations have been reported by numerous epidemiological studies, where asthma is more frequently diagnosed in boys during childhood due to smaller airway caliber and hormonal influences before puberty.[9] The predominance of children between 8 and 10 years in the present study is also consistent with previous Indian pediatric studies.

Nearly half of the children had a positive family history of asthma or atopy (50.8%), emphasizing the important contribution of genetic predisposition in disease development. Previous studies have consistently shown that children with one or both asthmatic parents are at substantially increased risk of developing asthma because of inherited susceptibility affecting airway inflammation and immune responses.[10]

Allergic rhinitis was observed in 48.3% of children, while atopic dermatitis and food allergy were reported in 21.7% and 15%, respectively. These findings support the concept of the "atopic march," in which eczema, food allergy, allergic rhinitis, and asthma frequently coexist. The coexistence of upper and lower airway inflammation highlights the importance of integrated management of allergic diseases to improve asthma outcomes.[11]

Environmental exposures constituted major modifiable risk factors in this study. Passive smoking was present in 39.2% and biomass fuel exposure in 35.8% of children. Exposure to tobacco smoke has been shown to impair lung growth, increase airway inflammation, and reduce responsiveness to inhaled corticosteroids. Similarly, biomass smoke exposure remains an important contributor to pediatric respiratory diseases in developing countries.[12]

Elevated serum IgE levels and eosinophilia were common laboratory findings, reflecting the allergic phenotype of childhood asthma. Elevated IgE was observed in 61.7% of patients, while increased eosinophil counts were found in more than half of the study population. These biomarkers have previously been associated with persistent airway inflammation, frequent exacerbations, and poorer asthma control.[13]

Pulmonary function testing demonstrated airflow limitation in a substantial proportion of children, with nearly half exhibiting FEV_1 values below 80% of predicted and over three-fourths showing significant bronchodilator reversibility. These findings support the usefulness of spirometry in confirming diagnosis and monitoring treatment response, as recommended by international asthma guidelines.[1]

One of the major strengths of this prospective study was the assessment of long-term outcomes over 12 months. The proportion of children with well-controlled asthma improved progressively from 18.3% at enrollment to 67.5% after one year, while uncontrolled asthma decreased from 43.4% to only 9.2%. This improvement likely reflects better medication adherence, reinforcement of inhaler technique, regular follow-up, and timely adjustment of controller therapy. Similar improvements have been reported in longitudinal cohort studies following implementation of structured asthma management programs.[14]

The average number of exacerbations, emergency visits, and hospital admissions remained relatively low during follow-up, while nearly four-fifths of children experienced no hospitalization over one year. Furthermore, improved lung function was observed in 65.8% of participants, indicating that sustained anti-inflammatory therapy can significantly improve pulmonary function and disease control.

Medication adherence emerged as one of the strongest predictors of favorable outcomes. Poor adherence was significantly associated with persistent uncontrolled asthma ($p<0.001$). Similar findings have been consistently demonstrated in previous studies, where inadequate adherence substantially increases the risk of exacerbations, emergency visits, and hospitalization.[15]

Passive smoking, family history of asthma, allergic rhinitis, and elevated IgE levels were also identified as independent predictors of poor asthma control. These findings emphasize that optimal asthma management should extend beyond

pharmacotherapy and include environmental control, smoking cessation counseling for family members, management of allergic comorbidities, and continuous patient education.

The study has certain limitations. It was conducted at a single tertiary care center with a relatively modest sample size, which may limit generalizability. Some specialized investigations, including allergy skin prick testing, were performed only in selected patients because of resource limitations. Additionally, quality-of-life assessment relied primarily on clinical evaluation rather than standardized validated questionnaires.

Nevertheless, the prospective design, systematic follow-up, comprehensive clinical assessment, and evaluation of multiple environmental and laboratory risk factors strengthen the reliability of the findings. The study provides valuable evidence supporting comprehensive asthma management strategies in pediatric populations.

Overall, the findings reinforce current international recommendations emphasizing early diagnosis, identification of modifiable risk factors, regular follow-up, optimization of inhaled corticosteroid therapy, and patient education to achieve sustained asthma control and improved long-term outcomes.

CONCLUSION

Childhood asthma is a common chronic respiratory disease with significant clinical and environmental determinants. This study demonstrated that regular follow-up, good treatment adherence, and appropriate controller therapy significantly improved asthma control, lung function, and quality of life while reducing exacerbations and hospitalizations. Passive smoking, family history of asthma, allergic rhinitis, elevated serum IgE levels, and poor medication adherence were significant predictors of poor asthma control. Early identification of risk factors and comprehensive guideline-based management are essential for achieving favorable long-term outcomes in children with asthma.

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