

Original Research

Received 30 June 2026

Revised 05 Aug 2026

Accepted 18 Aug 2026

Natural Resources for Human Health 2026, Vol. 6 (17s): 569–574

KEYWORDS:

asthma; children; school screening; peak expiratory flow rate; questionnaire

School-Based Screening for Early Asthma among Asymptomatic School Children in Western Uttar Pradesh: A Cross-Sectional Study

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ABSTRACT:

Background: Childhood asthma may remain unrecognized when symptoms are intermittent, mild or normalized by children and families. Schools provide an opportunity to identify children who may benefit from further respiratory evaluation. This study assessed the performance of a symptom-based asthma questionnaire in relation to peak expiratory flow rate (PEFR) among asymptomatic school children in Western Uttar Pradesh.

Methods: This observational cross-sectional study included 370 asymptomatic school children aged 8–14 years from a school in Greater Noida, Western Uttar Pradesh. Children with diagnosed asthma, respiratory medication use, acute or chronic respiratory illness, or active cough, wheeze or coryza were excluded. A 14-item American College of Allergy, Asthma and Immunology (ACAAI) asthma screening questionnaire was administered. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), area under the receiver operating characteristic curve (AUC), diagnostic accuracy and Cohen's kappa were calculated.

Results: The mean age was 12.06 ± 1.00 years; 222 (60.0%) participants were female. Eighty-three (22.43%) children screened positive on the questionnaire and 53 (14.32%) had deranged PEFR. Mean PEFR was 275 ± 76.66 L/min. Against the study-defined PEFR classification, questionnaire sensitivity was 73.58% (95% CI 59.67–84.74), specificity 86.12% (95% CI 81.82–89.73), PPV 46.99% (95% CI 35.93–58.26), and NPV 95.12% (95% CI 91.95–97.31). AUC was 0.80 (95% CI 0.75–0.84), diagnostic accuracy was 84.32%, and agreement was moderate ($\kappa=0.483$, $p<0.0001$).

Conclusion: The questionnaire identified a substantial group of children requiring further assessment and showed good discrimination against the study-defined PEFR

classification, with a high NPV. However, neither questionnaire positivity nor reduced PEFR should be interpreted as a definitive diagnosis of asthma. School-based screening may serve as an initial case-finding strategy when positive screens are followed by appropriate clinical assessment and confirmatory pulmonary function testing.

1. INTRODUCTION

Asthma is one of the most common chronic respiratory diseases of childhood and is characterized by variable respiratory symptoms and variable expiratory airflow limitation. Symptoms may include wheeze, cough, breathlessness and chest tightness, with their intensity and frequency varying over time. In children, intermittent symptoms and adaptation to activity limitation may result in under-recognition, while barriers to access and limited availability of objective testing can delay diagnosis [1-4].

The burden of childhood asthma is substantial globally and in India. Indian epidemiological studies have demonstrated considerable regional variation in prevalence and treatment practices, while school-based studies have repeatedly identified children with respiratory symptoms who may not have received a prior diagnosis. School health settings therefore represent a potentially useful point for case finding, particularly where access to formal pulmonary function testing is limited. [6-9]

Questionnaire-based screening is inexpensive, portable and suitable for administration to large numbers of school children. Symptom questionnaires can identify children reporting wheeze, cough, exercise-related respiratory difficulty, nocturnal symptoms and exposure-related complaints. However, questionnaire responses are subjective and may be influenced by recall, interpretation and awareness of respiratory symptoms [10-12].

Peak expiratory flow rate is another low-cost respiratory measurement that can be performed outside a pulmonary function laboratory. It provides an objective measure of maximal expiratory flow, but is effort-dependent and varies with age, sex and body size [13,14]. A reduced PEFR can therefore indicate possible airflow limitation but does not by itself establish asthma. Definitive asthma diagnosis generally requires clinical assessment together with objective evidence of variable expiratory airflow limitation where feasible. [15-17]

The present study was designed to screen asymptomatic school children aged 8-14 years in Greater Noida, Western Uttar Pradesh, using a 14-item ACAAI asthma screening questionnaire and PEFR measurement. The study additionally examined the agreement and diagnostic performance of the questionnaire against the study-defined PEFR classification. [18-20]

METHODS

This was an observational cross-sectional study conducted over 18 months in a school in Greater Noida, Western Uttar Pradesh, India. A total of 370 children were included. Children aged 8-14 years who were described as asymptomatic were included in the study. Children with a previous diagnosis of asthma, those taking medication for asthma or another respiratory illness, those with acute or chronic respiratory illness such as tuberculosis, and those actively experiencing cough, wheeze or coryza were excluded.

Institutional ethics committee approval was obtained before commencement of the study. Permission was obtained from the participating schools, and assent and parental consent were obtained from the participants.

A 14-item pre-validated asthma screening questionnaire curated by the American College of Allergy, Asthma and Immunology (ACAAI) for children aged 8-14 years was administered by the researcher. Items addressed respiratory symptoms and symptom triggers. More than five affirmative responses were classified as a positive questionnaire screen according to the study protocol [3,10-12].

Height and weight were measured in all participants and body mass index was calculated. PEFR was measured using a standard peak flow meter. Children stood upright with the mouthpiece correctly positioned and performed three readings. The highest reading was recorded as the final PEFR [2,3]. PEFR values below 80% of predicted were classified as deranged according to the study protocol. PEFR values below 80% of predicted were classified as deranged according to the study protocol [2,3].

Statistical analysis

Categorical variables were summarized as frequencies and percentages. Continuous variables were summarized as mean $\pm$ standard deviation and median with interquartile range. Normality was assessed using the Shapiro-Wilk test. Associations

between categorical variables were assessed using the chi-square test or Fisher exact test where appropriate. Independent t test or Mann–Whitney U test was used for continuous variables according to distribution. Cohen’s kappa was used to assess agreement between questionnaire screening and PEFr classification. Sensitivity, specificity, PPV, NPV, AUC and diagnostic accuracy were calculated. Pearson correlation was used to assess relationships between PEFr and anthropometric parameters. Analyses were performed using IBM SPSS Statistics version 25.0. A p value <0.05 was considered statistically significant.

RESULTS

Participant characteristics

The study included 370 children aged 8–14 years. Mean age was 12.06 ± 1.00 years. There were 222 (60.0%) females and 148 (40.0%) males. Most participants were aged 12 years and were enrolled in class 7 (Table 1).

Table 1. Baseline characteristics of the study population.

Characteristic	Value
Sample size	370
Age, mean $\pm$ SD	12.06 ± 1.00 years
Female	222 (60.0%)
Male	148 (40.0%)
Height, mean $\pm$ SD	146.89 ± 7.76 cm
Weight, mean $\pm$ SD	31.09 ± 11.31 kg
BMI, mean $\pm$ SD	26.42 ± 11.44 kg/m ²
PEFr, mean $\pm$ SD	275 ± 76.66 L/min

Questionnaire screening

Eighty-three of 370 children (22.43%) had more than five affirmative responses and were classified as questionnaire-positive. The remaining 287 (77.57%) were questionnaire-negative (Table 2).

Table 2. Distribution according to questionnaire screening status.

Questionnaire status	n	%
Positive	83	22.43
Negative	287	77.57
Total	370	100.00

PEFr classification

Fifty-three children (14.32%) had PEFr below 80% of predicted and were classified as having deranged PEFr (Table 3). The remaining 317 (85.68%) had PEFr within the study-defined normal range.

Table 3. Distribution according to PEFr classification

PEFr classification	n	%
Normal	317	85.68
Deranged (<80% predicted)	53	14.32
Total	370	100.00

Questionnaire and PEFr cross-tabulation

Among questionnaire-negative children, 273 (73.78% of the total sample) had normal PEFr and 14 (3.78%) had deranged PEFr. Among questionnaire-positive children, 44 (11.89%) had normal PEFr and 39 (10.54%) had deranged PEFr (Table 4).

Table 4. Cross-tabulation of questionnaire screening status and PEFr classification.

Questionnaire	PEFr normal	PEFr deranged	Total
Negative	273	14	287
Positive	44	39	83
Total	317	53	370

Diagnostic performance

Using the study-defined PEFR classification as the reference classification, questionnaire screening showed sensitivity of 73.58% and specificity of 86.12%. PPV was 46.99% and NPV was 95.12%. The AUC was 0.80, diagnostic accuracy was 84.32%, and agreement between the two screening classifications was moderate ($\kappa=0.483$, $p<0.0001$) (Table 5).

Table 5. Diagnostic performance of the questionnaire against the study-defined PEFR classification.

Measure	Estimate	95% CI
Sensitivity	73.58%	59.67–84.74
Specificity	86.12%	81.82–89.73
Positive predictive value	46.99%	35.93–58.26
Negative predictive value	95.12%	91.95–97.31
AUC	0.80	0.75–0.84
Diagnostic accuracy	84.32%	—
Cohen's kappa	0.483	$p<0.0001$

Demographic associations with PEFR

There was no statistically significant association between PEFR classification and age ($p=0.073$), sex ($p=0.332$), or class ($p=0.074$) (Table 6).

Table 6. Association of demographic characteristics with PEFR classification.

Variable	p value
Age	0.073
Sex	0.332
Class	0.074

DISCUSSION

This school-based cross-sectional study evaluated a symptom-based asthma questionnaire together with PEFR in 370 asymptomatic school children aged 8–14 years in Greater Noida, Western Uttar Pradesh. The study identified questionnaire positivity in 22.43% of participants and deranged PEFR in 14.32%. The questionnaire showed moderate sensitivity and high specificity against the study-defined PEFR classification, with a high NPV and moderate agreement [1–9].

Although the children were asymptomatic at the time of screening, 22.43% had more than five affirmative responses on the questionnaire. This reflects the fact that the questionnaire asked about symptoms that may occur intermittently rather than only symptoms present on the day of examination.

The most frequently reported questionnaire item was difficulty breathing around smoke or odors (38.65%), followed by frequent cough (33.51%) and difficulty breathing or coughing while climbing stairs (28.65%). Chest tightness or pain was reported by 27.84%, while 27.03% reported breathing difficulty or coughing during play. These responses indicate that respiratory symptoms can be elicited even among children not presenting with active respiratory illness [5,6,18].

The questionnaire demonstrated a sensitivity of 73.58% and specificity of 86.12% when PEFR classification was used as the reference classification. The high NPV of 95.12% means that, within this study population and against this reference classification, most children with a negative questionnaire did not have deranged PEFR. The PPV was lower at 46.99%, indicating that a substantial proportion of questionnaire-positive children did not have PEFR below the study threshold. [2,3,10–12]

These findings need to be considered in light of the reference measure used in this study. PEFR is effort-dependent and is influenced by technique, age, sex and body size. A PEFR below 80% of predicted does not by itself diagnose asthma, and a child with asthma may have a normal PEFR at a single assessment. Therefore, the sensitivity, specificity and predictive values reported here describe the performance of the questionnaire against the study-defined PEFR classification, rather than against confirmed asthma.

The kappa coefficient of 0.483 indicated moderate agreement beyond chance between the questionnaire and PEFR classifications. The two methods assess different aspects of respiratory health. The questionnaire captures previous and

intermittent symptoms, whereas PEFr reflects expiratory flow at one point in time. Some degree of disagreement between them is therefore understandable.

The 44 children with a positive questionnaire but normal PEFr may have had intermittent symptoms that were not accompanied by reduced flow on the day of testing. Some may also have had symptoms unrelated to asthma. The 14 children with a negative questionnaire but deranged PEFr may reflect limited symptom reporting or airflow limitation without current symptoms. These findings suggest that the questionnaire and PEFr provide complementary information.

Schools provide access to large groups of children and may therefore be useful for initial case finding. In this study, a questionnaire followed by PEFr identified children who would otherwise not have been identified on the basis of symptoms present on the screening day. Whether such a strategy is cost-effective or improves asthma detection at the population level would require further study.

Any child identified through screening should undergo appropriate clinical assessment rather than being labelled as having asthma solely on the basis of a questionnaire or PEFr result. Where available, spirometry with bronchodilator assessment and other investigations should be used according to clinical context and pediatric asthma diagnostic guidance. [1–3]

Strengths

Strengths include the school-based setting, inclusion of children without known asthma, standardized administration of a 14-item questionnaire, and objective PEFr measurement with three attempts and retention of the highest reading. The study also reports several complementary measures of questionnaire performance and agreement. [2,3]

Limitations

The cross-sectional design prevents assessment of temporal variability and causality. The study was conducted in a selected school in Western Uttar Pradesh, limiting generalizability. Questionnaire responses may be affected by recall and reporting bias. PEFr is effort-dependent and may vary with technique and cooperation. Environmental exposures, pollution levels, season and recent respiratory infections were not systematically controlled. [1–4,6–9]

Most importantly, confirmatory spirometry, bronchodilator reversibility testing and FeNO were not systematically performed. Therefore, the study cannot determine the prevalence of confirmed asthma or the diagnostic accuracy of the questionnaire for asthma itself. The PEFr threshold should be understood as a screening classification used within this study, not as a diagnostic gold standard. [1–3]

CONCLUSION

The asthma questionnaire showed 73.58% sensitivity, 86.12% specificity and 95.12% NPV against the study-defined PEFr classification, with moderate agreement ($\kappa=0.483$). Hence, the symptom related asthma questionnaire may be useful for initial screening and case finding in school children. Children with a positive screen should undergo clinical assessment and, where appropriate, confirmatory pulmonary function testing.

DECLARATIONS

Consent for publication: Yes

Funding: No specific funding was received for this study.

Competing interests: NIL

Acknowledgements: The authors acknowledge the participating school, students and families, and the Department of Pediatrics, School of Medical Sciences and Research, Sharda University, Greater Noida.

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