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The Correlation of Allergic Sensitization (IgE and Eosinophil Count) with Wheezing in School-Aged Children and Adolescents in Sulaimani City

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ABSTRACT

Introduction:
Wheezing in children is a common symptom of respiratory disorders and is associated with allergic sensitization. This study aimed to evaluate the relationship between biomarkers of allergic sensitization (serum Immunoglobulin E (IgE) and peripheral eosinophil count) and the severity of wheezing symptoms among school-aged children and adolescents in Sulaimani City.

Materials and Methods:
A cross-sectional study was conducted from January to June 2025 at two major pediatric respiratory centers. Ninety-five children aged 6–18 years with documented wheeze were recruited consecutively. Demographics, clinical history, environmental exposures, and spirometry data were collected. Serum IgE levels and eosinophil counts were measured. Continuous variables were reported as mean ± standard deviation, while categorical variables were presented as frequencies and percentages Spirometry results, both pre- and post-bronchodilator, were categorized into severe, moderate, or mild obstruction based on FEV1 values.

Results:
The mean age of the subjects was 9.6 years, with 71.6% being male. In a study of 66 children with asthma, pre- and post-bronchodilator spirometry revealed a reduction in the proportion of children with severe persistent asthma after bronchodilator use (from 25.8% to underwent 13.3%). Among the 30 children post-bronchodilator testing, 64.3% showed a positive response (≥12% increase in FEV1), indicating reversible airway obstruction. These results highlight the effectiveness of bronchodilators in improving pulmonary function in children with asthma.

Conclusion:
Higher IgE and eosinophil levels strongly correlate with wheezing severity. Including these biomarkers in routine assessment is advisable, especially where environmental or family atopic risk is high.

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Introduction

Our study was conducted among children with upper respiratory symptoms, and their symptoms had an impact on both the children's quality of life and their families' socioeconomic status. The most common symptoms are cough, shortness of breath, and wheeze. The study aimed to investigate the relationship between these symptoms and eosinophil count, serum IgE, spirometry results, and the eventual diagnosis of asthma or allergy-associated asthma. Allergic diseases have emerged as a major and escalating global health concern, imposing a substantial burden on patients and healthcare systems. Affecting individuals across all age groups, allergic conditions are increasingly prevalent in both developed and developing countries, particularly among children and adolescents (1).

Wheezing in school-aged children is not only a common symptom of asthma but also a potential indicator of underlying allergic airway inflammation (2). It is estimated that up to 30–50% of children experience at least one episode of wheezing before school age, and in a significant proportion, recurrent wheezing evolves into persistent asthma, particularly when driven by allergic sensitization (3,4).

Allergic sensitization, marked by elevated total serum IgE and eosinophilia, reflects a Th2-polarized immune response to otherwise innocuous environmental allergens, such as house dust mites, pollens, or animal dander.

This immune dysregulation contributes to airway hyperresponsiveness, mucus hypersecretion, and bronchoconstriction, which clinically manifest as wheezing (5).

Allergic asthma in children is the result of complex pathophysiological changes, including both endotypes and phenotypes, leading to disease complications. The interactions among endotype, phenotypes, genotype, and environmental exposures together contribute to immune dysregulation and increased sensitivity to antigens that are typically harmless, known as allergens (6). In the era of immunological changes and allergic sensitization, allergen-specific immunoglobulin E (IgE) is produced, accompanied by the activation of T-helper type 2 (Th2) cells and their cytokines (7). The prevalence of asthma, allergic rhinitis, allergic conjunctivitis, food allergies, and nonautomatic wheezing has increased over the last decades, especially in industrialized and crowded regions and cities around the world. Markedly over the past few decades, especially in urbanized and industrialized environments (8). The hygiene hypothesis suggests that reduced exposure to early-life pathogens and commensal microbes skews the immune system toward Th2 dominance, enhancing the risk for allergic sensitization and atopy (1). Environmental factors, both indoors and outdoors, air pollution, smoking, and dietary habits promote epithelial damage, oxidative stress, and chronic inflammation (9,10).

Among pediatric populations, wheezing represents one of the earliest and most common clinical manifestations of obstruction and allergic airway disease. Allergy biomarkers like IgE and Eosinophilia could participate in the first impression about the early onset of asthma in this group of children. Despite extensive investigation of these biomarkers individually, limited studies have explored their combined utility in predicting clinical phenotypes and pulmonary dysfunction related to wheezing in children, particularly in underrepresented regions such as the Middle East. IgE serves as a crucial biomarker in allergic diseases, with elevated levels correlating significantly with respiratory symptoms, including wheeze and asthma severity (11). Concurrently, eosinophils contribute to allergic airway inflammation by releasing cytotoxic mediators that damage the respiratory epithelium and amplify bronchial hyper-responsivity (12). Almost half of all infants experience wheezing during their first year of life, and a subset goes on to develop persistent asthma marked by bronchial hyperreactivity and airway remodeling (13). In this age, inadequate therapy of wheezing, elevated biomarkers, and bronchial hyper-responsivity lead to early asthma development. In some cases, various mechanical or infectious causes, IgE-mediated sensitization, and eosinophilic inflammation remain key drivers in many cases of recurrent and severe episodes (14). This field encompasses a substantial array of

topics, including allergic-associated asthma, IgE-associated asthma, and eosinophilic asthma. Our study addresses the same scientific trend and direction with critical thinking and both diagnostic and therapeutic approaches in Kurdistan-Sulaimani City. Through the integration of clinical, environmental, and immunological data. Performing spirometry for children above 6 years contributes to the correct diagnosis and, of course, adequate necessary drug treatment and future strategies among these children and children like them inside the community. GINA 2024 has introduced a revised diagnostic flow chart for assessing children aged 6 to 11 years and adolescents who present with recurrent or chronic respiratory symptoms while documenting bronchodilator reversibility remains the gold standard for diagnosing asthma, it may be impractical in real-world clinical settings due to inconsistency in the availability of spirometry devices and a lack of adequate training among healthcare personnel regarding the correct technique and interpretation of spirometry results. A survey conducted among healthcare practitioners in India revealed a wide variation in the use of spirometry in clinical practice, ranging from 72% among chest physicians to 12% among general practitioners (15). The National Asthma Education and Prevention Program (NAEPP) was initiated in 1989. Diagnosis is based on clinical presentation, response to bronchodilators and inhaled corticosteroids (ICS), and spirometric pulmonary function test results (16). Asthma is classified according to symptom frequency, forced expiratory volume in 1 second (FEV_1), peak expiratory flow (PEF), and atopic versus non-atopic etiology. Many of the reviewed guidelines are similar to the GINA and NICE guidelines (17), and the severity classification here is the same as others' Severity classification Intermittent vs persistent (mild, moderate, severe), one of the characteristics of asthma is Intermittent, periodic, or attacks of symptoms. Guidelines should not be rigidly followed; factors such as resources, family attitudes, and compliance must be considered. In-depth counselling and the establishment of a good rapport are key components to successful management of this prevalent and challenging disease. The 2025 edition of the GINA Report confirms that it is possible to diagnose asthma in this age group and clearly outlines that this requires meeting three specific criteria (18). Recurrent acute episodes of wheezing, or at least one acute episode of wheezing accompanied by asthma-like symptoms between episodes.

1. No other likely alternative cause for the respiratory symptoms.
2. Timely clinical response of respiratory signs or symptoms to asthma treatment. Any of the following options:

- Rapid response to SABA (short-acting beta2-agonist) during acute wheezing episodes in a healthcare setting (within minutes), or, in more severe cases, within 3–4 hours after starting treatment with SABA and oral corticosteroids (OCS).
- Rapid response to SABA at home, with symptom improvement within minutes (18).

Decrease in the frequency or severity of acute wheezing episodes and/or symptoms between episodes during a 2–3-month diagnostic trial with daily inhaled corticosteroids (ICS). Asthma severity is often classified based on the percentage of the predicted FEV1 value.

The expected value is based on the child's age, height, sex, and ethnicity. A lower FEV1 generally indicates more severe airflow obstruction. According to various guidelines, including those from the National Asthma Education and Prevention Program (NAEPP), the classification is typically as follows:

Mild Intermittent Asthma: FEV1 is at least 80% of the predicted value. Mild Persistent Asthma: FEV1 is at least 80% of the predicted value. Moderate Persistent Asthma: FEV1 is between 60% and 80% of the predicted value. Severe Persistent Asthma: FEV1 is less than 60% of the predicted (19). In the context of Sulaimani City, the prevalence and characteristics of allergic asthma remain underexplored, despite the region’s unique environmental exposures such as urban air pollution, household heating by gas, and high population density. Therefore, this study not only investigates the relationship between allergic biomarkers (serum IgE and eosinophil count) and wheezing severity but

also provides region-specific insights by comparing these immunologic and environmental characteristics with findings reported from other geographical areas. This approach enables a better understanding of how local environmental and genetic factors might influence allergic sensitization patterns among Kurdish children

Materials and Methods

Ethical Considerations: Ethical approval was granted by the Ethics Review Committee of the University of Sulaimani (Reference No.: ABC). Written informed consent was obtained from legal guardians, and assent was secured from participants aged 12 years and older.

Cross-sectional design to examine the association between markers of allergic sensitization—specifically total serum IgE and peripheral blood eosinophil count—and wheezing severity in school-aged children and adolescents ،aged 6 to 18 years who presented with active wheezing, confirmed via auscultation by attending pediatricians. Participants were recruited consecutively from outpatient visits during routine clinic hours. The investigation was conducted over six months (January–June 2025) to account for seasonal respiratory variations. Data were collected at two specialized respiratory care centers in Sulaimani City, Iraq:

the Dr. Jamal Ahmed Rasheed Pediatric Teaching Hospital (Outpatient Respiratory Clinic) and the Sulaimani Respiratory Center. Written informed consent from a parent or legal guardian, while children aged 12 and above provided written assent in accordance with ethical guidelines for pediatric research. We excluded chronic respiratory diseases, structural cardiac anomalies, or primary immunodeficiency syndromes and patients on permanent systemic corticosteroids, immunosuppressants, or allergy-modifying therapy within four weeks before enrollment. Children with cognitive, physical, or developmental disorders limiting their ability to cooperate with spirometry or complete interview-based procedures were also excluded. Parents or guardians were interviewed to obtain age, sex, family members, residence (urban vs. rural), socioeconomic status, and parental education. Additionally, to exclude non-asthmatic causes of wheezing (e.g., foreign body aspiration, congenital airway anomalies, structural cardiac disease, or bronchiectasis), all participants underwent thorough clinical evaluation by a pediatric pulmonologist. This included detailed history (e.g., sudden onset, focal wheeze, failure to thrive), physical examination (e.g., asymmetric breath sounds, murmurs), and, when clinically indicated, chest X-ray and echocardiography. Children with signs suggestive of alternative diagnoses (e.g., unilateral wheeze, digital clubbing, cyanosis, or abnormal cardiac findings) were excluded from the study. Chest imaging was performed in 22 children based on clinical suspicion, and none showed evidence of foreign body, heart failure, or structural lung disease. Clinical History and Respiratory Symptoms:

A comprehensive clinical history was collected for each participant, documenting the frequency and persistence of wheezing, nocturnal symptoms, response to bronchodilators, and any previous hospital admissions. Additional records included prior diagnoses of asthma or other atopic conditions, such as eczema and hay fever, verified through medical documentation and physician notes.

Environmental and Familial Risk Factors: Information was obtained regarding exposure to household smoking, domestic pets, mold, scented products, and the types of heating methods used at home. Details on proximity to traffic and family history of asthma or other atopic conditions in first-degree relatives were also recorded.

Nutritional and Early Life History: Nutritional status was assessed based on body mass index (BMI), using WHO age- and sex-specific percentiles. Data collection included duration of breastfeeding, daycare attendance, and any history of early antibiotic use. Laboratory Testing:

Peripheral blood samples were analyzed to determine total serum IgE levels using ELISA-based immunoassays. For children aged 6–9 years, normal IgE was defined as below 90 IU/mL, with high values exceeding 90 IU/mL. For those aged 10–15 years, normal was defined as below 200 IU/mL, and high as 200 IU/mL or greater. Absolute eosinophil counts exceeding 500 cells/μL were considered elevated (20).

Pulmonary Function Testing: Spirometry was performed using a portable spirometer (ndd EasyOne Pro®) in accordance with American Thoracic Society/European Respiratory Society (ATS/ERS) 2019 guidelines (21). Only children aged ≥6 years who could perform at least three acceptable and two reproducible maneuvers were included in the analysis. FEV_1 values were expressed as a percentage of predicted normal values based on age, sex, height, and ethnicity, using the Global Lung Function Initiative (GLI-2012) pediatric reference equations (22). Airflow obstruction was classified as: mild (FEV_1 ≥80% predicted), moderate (FEV_1 60–79% predicted), or severe (FEV_1 <60% predicted) (23).

Bronchodilator reversibility was defined as an increase in FEV_1 of ≥12% and ≥200 mL from baseline after administration of 200–400 µg salbutamol via spacer, consistent with GINA 2025 recommendations (24). Due to the developmental limitations in younger children, only 66 out of 95 participants (69.5%) achieved technically acceptable curves; of these, 30 underwent both pre- and post-bronchodilator testing.

Statistical Analysis: All analyses were conducted using IBM SPSS software (version 27.0). Continuous variables were reported as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Comparisons of normal and high IgE and eosinophil levels were made using independent samples t-tests. Spirometry results, both pre- and post-bronchodilator, were categorized into severe, moderate, or mild obstruction based on FEV1 values.

Results

The study included 95 school-aged children and adolescents with a mean age of 9.64 ± 2.81 years. The majority of participants were male, 68 (71.6%), while females made up 27 (28.4%). Most children belonged to families with a normal socioeconomic status, 81 (85.3%), followed by those from low-income backgrounds, 13 (13.7%). In terms of residence, urban participants were predominant, 66 (69.5%), compared to rural residents, 29 (30.5%). Regarding family size, having one sibling, 34 (35.8%), or two siblings, 31 (32.6%), was more common than having no siblings or larger numbers of siblings (Table 1).

Table 1. Socio-demographics characteristics in children.

Variable		**Frequency (Percent)**
Age (years)		**9.64 ± 2.805**
Sex	Male	68 (71.6%)
	Female	27 (28.4%)
Socioeconomic Status	Low	13 (13.7%)
	Normal	81 (85.3%)
	High	1 (1.1%)
Location	Urban	66 (69.5%)
	Rural	29 (30.5%)
Number of siblings	0	7 (7.4%)
	1	34 (35.8%)
	2	31 (32.6%)
	3	14 (14.7%)
	4	8 (8.4%)
	5	1 (1.1%)

All participating children had a history of wheezing, 95 (100%), and an established asthma or respiratory diagnosis, 95 (100%). The majority reported wheezing affecting sleep or daily activity, 87 (91.6%), and most experienced cough associated with wheeze, 93 (97.9%). Hospitalization due to wheezing was noted in 65 (68.4%) of the participants. Seasonal worsening of wheezing was reported by 82 (86.3%), and a comparable proportion had known allergies, 82 (86.3%). Family history of allergy or asthma was highly prevalent, 89 (93.7%). Eczema or hay fever was documented in 77 (81.1%) of the children, while nasal symptoms were also common, affecting 80 (84.2%). Regarding subjective allergy trends, nearly half reported improvement, 44 (46.3%), whereas 29 (30.5%) described worsening symptoms. All subjects were using inhaled

corticosteroids, bronchodilators, and nebulizers or metered-dose inhalers, 95 (100%) each. The mean IgE level was 515.79 ± 572.27 IU/mL, with elevated values more frequent among children aged 6–9 years, 38 (79.2%), and those aged 10–15 years, 34 (54.8%). The mean eosinophil count was 455.74 ± 491.61 cells/μL, with normal counts (≤ 500 cells/μL) observed in 63 (66.3%) of the subjects (Table 2).

Table 2. Respiratory symptoms and allergies in children.

Variable		Frequency (Percent)
Ever wheezing	Yes	95 (100%)
	No	0
Impact on sleep/daily life	Yes	87 (91.6%)
	Some times	8 (8.4%)
Asthma or respiratory diagnosis	Yes	95 (100%)
	No	0
Cough with wheeze	Yes	93 (97.9%)
	Some times	2 (2.1%)
Hospitalized for wheezing	Yes	65 (68.4%)
	No	30 (31.6%)
Wheezing seasonal change	Yes	82 (86.3%)
	No	2 (2.1%)
	Mybe	11 (1.6%)
Known allergies	Yes	82 (86.3%)
	No	13 (13.7%)
Family history of allergy/asthma	Yes	89 (93.7%)
	No	6 (6.3%)
Eczema or hay fever	Yes	77 (81.1%)
	No	18 (18.9%)
Allergy trend	Better	44 (46.3%)
	Worse	29 (30.5%)
	Same	22 (23.2%)
Nasal symptoms	Yes	80 (84.2%)
	No	15 (15.8%)
Eye symptoms	Yes	47 (49.5%)
	No	48 (50.5%)
Inhaled corticosteroids	Yes	95 (100%)
	No	0
Bronchodilators	Yes	95 (100%)
	No	0
Nebulizers and metered dose inhalers (MDI)	Yes	95 (100%)
	No	0
IgE result		515.79 ± 572.274
Age group (6-9) year	≤ 90 (Normal)	10 (20.8%)
	≥ 91 (High)	38 (79.2%)
Age group (10-15) year	≤ 200 (Normal)	13 (39.4%)
	≥ 201 (High)	34 (54.8%)
Eosinophil count		455.74 ± 491.605
Category Eosinophil count	≤ 500 (Normal)	63 (66.3%)
	≥ 501 (High)	32 (33.7%)

Most participating children lived in homes without household smokers, 71 (74.7%), and without pets, 83 (87.4%). Environmental pollution exposure was reported by 40 (42.1%) of families. The majority engaged in physical activity rarely, 62 (65.3%), while only a minority exercised weekly, 24 (25.3%). All households used gas

for heating, 95 (100%). Damp or mold exposure was observed in 32 (33.7%) of homes. Cleaning was most commonly performed on a weekly basis, 65 (68.4%). More than half of participants' houses were not located near busy roads, 61 (64.2%), although many lived in carpeted residences, 67 (70.5%). The use of scented products was reported by a substantial portion of households, 64 (67.4%). Overall, housing was predominantly classified as not crowded, 58 (61.1%), with fewer living in crowded conditions, 37 (38.9%) (Table 3).

Table 3. Housing characteristics in terms of living conditions and pollution

Variable		Frequency (Percent)
Household smoker	Yes	24 (25.3%)
	No	71 (74.7%)
Pets at home	Yes	12 (12.6%)
	No	83 (87.4%)
Environmental pollution	Yes	40 (42.1%)
	No	55 (47.9%)
Exercise frequency	Daily	7 (7.4%)
	Weekly	24 (25.3%)
	Monthly	2 (2.1%)
	Rarely	62 (65.3%)
Heating type	Gas	95 (100%)
Damp/mold exposure	Yes	32 (33.7%)
	No	63 (66.3%)
Cleaning frequency	Daily	29 (30.5%)
	Weekly	65 (68.4%)
	Monthly	1 (1.1%)
Near busy road	Yes	34 (35.8%)
	No	61 (64.2%)
Carpeted home	Yes	67 (70.5%)
	No	28 (29.5%)
Use scented products	Yes	64 (67.4%)
	No	31 (32.6%)
Housing condition	Crowded	37 (38.9%)
	Not crowded	58 (61.1%)

Immunization status is presented in Figure 1. 3 (3.2%) children had no previous immunization, immunization status was complete in 90 (94.7%) children, and incomplete immunization was reported in 2 (2.1%) children.

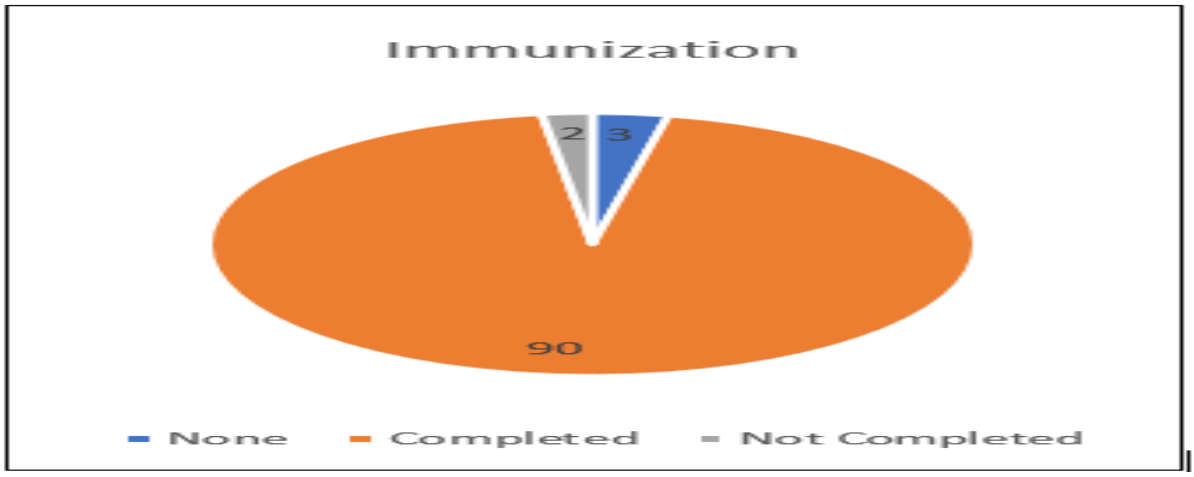

Figure 1. Immunization status in children

Nutritional status and BMI assessment indicated that 2 (2.1%) children were underweight, 65 (68.4%) had normal BMI, 17 (17.9%) were overweight, and 11 (11.6%) were obese (Figure 2).

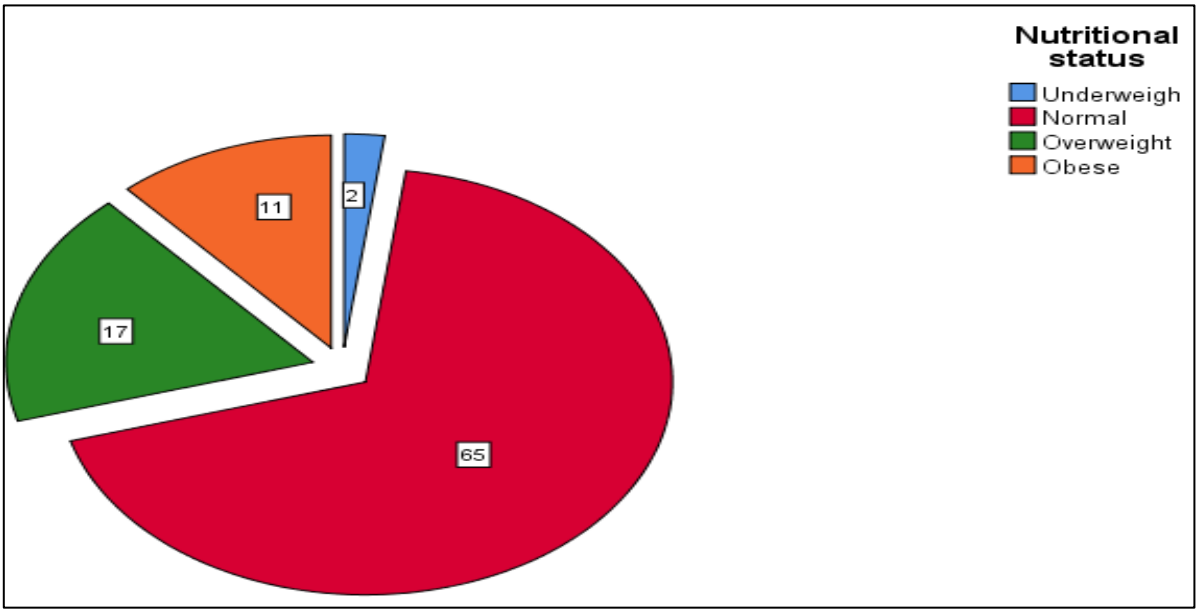

Figure 2. Nutritional status in children

Based on spirometric assessment, of the 66 children who completed pre-bronchodilator testing, mild persistent asthma with $FEV_1 \geq 80\%$ of the predicted value was observed in 27 (40.9%), moderate persistent asthma with FEV_1 between 60–80% in 22 (33.3%), and severe persistent asthma with $FEV_1 < 60\%$ in 17 (25.8%). Among the 30 children who underwent post-bronchodilator testing, mild persistent asthma remained the most frequent category, observed in 13 (43.3%), followed by moderate persistent asthma in 13 (43.3%) and severe persistent asthma in 4 (13.3%). Regarding bronchodilator responsiveness, assessed in 28 participants, a positive response with an increase in $FEV_1 \geq 12\%$ was documented in 18 (64.3%), while 10 (35.7%) demonstrated a negative response with < 12% change (Table 4).

Table 4. Pre and after spirometry data and % change in FEV1 in children.

Variable		Frequency (Percent)
Pre-spirometry FEV n = 66	Mild Persistent Asthma: FEV1 is at least 80% of the predicted value	27 (40.9%)
	Moderate Persistent Asthma: FEV1 is between 60% and 80% of the predicted value	22 (33.3%)
	Severe Persistent Asthma: FEV1 is less than 60% of the predicted	17 (25.8%)
Post-bronchodilator FEV n = 30	Mild Persistent Asthma: FEV1 is at least 80% of the predicted value	13 (43.3%)
	Moderate Persistent Asthma: FEV1 is between 60% and 80% of the predicted value.	13 (43.3%)
	Severe Persistent Asthma: FEV1 is less than 60% of the predicted	4 (13.3%)
% CHANGE IN FEV1 n = 28	< 12% (Negative)	10 (35.7%)
	≥ 12% (Positive)	18 (64.3%)

Discussion

Wheezing remains a significant clinical concern in pediatric respiratory health, often indicating underlying allergic sensitization or asthma (2). This study investigated the relationship between two key biomarkers IgE and eosinophil counts and the severity of wheezing in school-aged children and adolescents. The findings revealed that elevated levels of both IgE and

eosinophils were common among children experiencing wheeze, particularly those with moderate to severe symptoms. The study further identified environmental exposures and a strong family history of allergy as prevalent risk factors.

The elevated IgE levels observed in the younger children in this study are consistent with previous research. For example, Akinbami et al. (2016) highlighted that 70–80% of children with asthma in the United States had abnormally high serum IgE concentrations, which were strongly associated with symptom severity (25).

Similarly, the current findings showed that a very high proportion of the 6–9-year age group had IgE values above 90 IU/mL, reinforcing the association between atopy and respiratory symptoms. The high rate may reflect environmental and genetic factors unique to the Sulaimani region, including urban pollution and familial predisposition. In contrast, Hameed et al. (2019) in Iraq reported comparatively lower IgE levels, suggesting that regional variations, differing clinical thresholds, and diagnostic settings may influence IgE expression (26).

Furthermore, Rezwan et al. (2025) demonstrated a strong correlation between elevated IgE levels and asthma severity, corroborating the present observation that severe wheeze tracks closely with heightened allergen sensitization (27). Eosinophilia (defined as eosinophil count >500 cells/μL) was observed in one-third of the children, further demonstrating the inflammatory nature of their condition. This finding is in close agreement with Bleecker et al. (2023), who reported that 42.2% of children with asthma in the UK also had elevated eosinophil counts, which were predictive of hospitalization risk (28). Similarly, Ebrahimi et al. (2023) in Iran found a significant association between peripheral eosinophils and asthma severity in children, affirming the role of eosinophils as effector cells in airway inflammation (29). However, unlike the findings of Fayezi et al. (2021), which did not find a strong relationship between eosinophil levels and bronchodilator response, this study identified improvements in post-bronchodilator FEV_1 in individuals with elevated eosinophil counts, suggesting a partially reversible obstruction likely mediated by eosinophilic activity (30).

Spirometry data supported the clinical findings, with a substantial portion of participants exhibiting variable grades of airway obstruction, most notably reversible upon bronchodilator administration. Similar findings were reported by Coverstone et al. (2019) and Milanese et al. (2004), who observed significant bronchodilator responsiveness in wheezy children with atopic profiles. Given the difficulties of performing spirometry, its incompleteness in a large number of children, and the novelty of the method in Kurdistan, the changes made will not be very valid, but some changes were visible, and various factors could be influential (31). Rutting et al. (2022) emphasize that significant reversibility following bronchodilation solidifies the role of spirometry in identifying asthma phenotypes, especially in children with persistent wheezing (32).

Environmental risk factors such as exposure to household smoking, carpeting, the use of scented products, and proximity to traffic were commonly reported among the children's households. These factors have been consistently identified in the literature as exacerbating agents in allergic airway diseases. For example, Taherian et al. (2024) (33), and Wang et al. (2024) (34), emphasized the impact of air pollution and indoor allergens on asthma incidence and severity. Additionally, genetic predisposition played a considerable role, evidenced by the high prevalence of family history of asthma and allergy. This pattern aligns with the findings of Labyad et al. (2025), who reported similar genetic trends in Moroccan children with asthma (35). Exposure to environmental tobacco smoke, as described by Pattemore et al. (2018), further correlates with frequent hospitalizations and severity of symptoms, aligning with the admission patterns identified in this study (36). On a positive note, high rates of breastfeeding in the study cohort might have contributed protective immunological factors, as supported by Roff et al. (2025) (37), and Korevaar et al. (2023) (38). However, the concurrent high rate of early-life antibiotic use reflects the

observations of Bentouhami et al. (2023), who emphasized the adverse impact of microbiome disruption on immune system development (39).

An important limitation of this study is the lack of detailed information regarding the duration, dosage, and adherence to inhaled corticosteroid therapy among participants. All children in our cohort were receiving ICS treatment at enrollment, which may have influenced the biomarker levels we observed. Inhaled corticosteroids are known to suppress eosinophilic airway inflammation and can reduce peripheral blood eosinophil counts, potentially leading to an underestimation of the true degree of eosinophilic inflammation in some participants (40,41).

The fact that we still observed elevated IgE and eosinophil levels in a substantial proportion of treated children suggests that these biomarkers retain clinical relevance even in the context of ongoing therapy.

Nevertheless, future studies should systematically document treatment regimens and consider stratifying analyses by treatment intensity and duration to better understand the independent contribution of allergic sensitization markers to disease severity.

Additionally, the timing of biomarker measurement in relation to acute exacerbations versus stable disease periods may influence results and warrants consideration in future research designs. This study has several limitations that warrant consideration. First, the lack of detailed data on inhaled corticosteroid (ICS) use, including dosage, duration, and adherence, may have confounded biomarker levels, as ICS therapy is known to suppress eosinophil counts and potentially mask true allergic inflammation. Future studies should systematically document treatment regimens to adjust for these effects and clarify the independent role of IgE and eosinophils in disease severity. The cross-sectional design precludes causal inference between allergic sensitization and wheezing progression; prospective longitudinal studies are therefore needed to track biomarker trajectories alongside clinical outcomes over time.

Additionally, recruitment from clinical settings likely overrepresented children with more severe symptoms, limiting generalizability; community-based cohort studies would better capture the full spectrum of wheezing phenotypes in the general pediatric population. The modest sample size and reliance solely on total IgE and eosinophil counts, without allergen-specific IgE, skin prick testing, or fractional exhaled nitric oxide (FeNO), also restrict phenotypic precision. Incorporating these additional atopy assessments in future work will enable more accurate endotyping and personalized management strategies. Finally, prior corticosteroid use among some participants may have influenced biomarker levels, though this reflects real-world clinical practice and enhances external validity.

Conclusions

The results show a strong link between higher allergic sensitization markers and increased wheezing severity in children. Measuring serum IgE and eosinophils can improve diagnosis and management. These findings stress the role of genetics and environment in disease development and support efforts to reduce environmental risks for children's respiratory health. Importantly, integrating total IgE and absolute eosinophil count into routine clinical evaluation, especially in resource-limited settings where spirometry is unavailable, can enhance early identification of allergic asthma and guide targeted therapeutic interventions.

Conflict of interest: All authors declare no conflict of interest.

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