Asthma Uncovered: A Comprehensive Look at Epidemiology, Pathophysiology, and Diagnosis

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PRACTICE GAP

Asthma is the most common chronic respiratory disease in children. Advances in understanding its pathophysiology, along with emerging therapies and updated treatment strategies, underscore the importance of staying current with evidence-based care. However, many primary care professionals may still rely on outdated guidelines.

OBJECTIVES *After completing this article, readers should be able to:*

1. Describe the underlying pathophysiology of asthma.
2. Identify key clinical and diagnostic features of asthma in children and adolescents.
3. Recognize other conditions in the differential diagnosis of asthma.

INTRODUCTION

Asthma affects nearly 5 million children and over 20 million adults in the United States (US), making it one of the leading chronic diseases.[1] Asthma is characterized by chronic airway inflammation and reversible obstruction triggered by factors such as allergens, infections, and irritants. Signs and symptoms include wheezing, shortness of breath, chest tightness, and coughing, which can vary in severity. Asthma is controllable through trigger avoidance and by adhering to appropriate medical care.

Guidelines, including those from the National Heart, Lung, and Blood Institute (NHLBI) and Global Initiative for Asthma (GINA), offer evidence-based recommendations for the diagnosis and management of asthma.[2–4] Key updates include single maintenance and reliever therapy (SMART) with inhaled corticosteroid-formoterol combination inhalers. Additionally, there are several predictive tools and diagnostic tests that can assist the provider in identifying asthma.

Despite the availability of guidelines, predictive tools, and effective treatments, asthma imposes a significant burden on patients, caregivers, schools, and the health care system. Asthma-related costs in the US—including missed school and work, health care expenses, and mortality—exceed $80 billion annually.[5] Over the next 20 years, uncontrolled asthma is projected to contribute an estimated $964 billion

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ABBREVIATIONS

AAP	asthma action plan
ACT	asthma control test
AQI	air quality index
ED	emergency department
GINA	Global Initiative for Asthma
ICS	inhaled corticosteroid
LABA	long-acting β-2 agonist
NHLBI	National Heart, Lung, and Blood Institute
PFT	pulmonary function testing
SABA	short-acting β-2 agonist
SMART	single maintenance and reliever therapy

in additional costs.[6] Racial and ethnic disparities persist, with Non-Hispanic Black children and those with lower socioeconomic status experiencing more severe asthma symptoms.[7,8] Clearly, there is much more to be done to reduce the impact of asthma.

EPIDEMIOLOGY AND PREVALENCE

According to the most recent data from the Centers for Disease Control and Prevention (CDC), asthma affects one in every 12 children aged 0 to 17 years, which amounts to over 4.6 million children in the US.[8] In childhood, asthma prevalence is higher among males (9%) than females (7%), whereas in adulthood, both the prevalence and severity are greater among women.[9,10] Asthma prevalence shows significant disparities, with higher rates among children with limited resources, those in urban areas, and specific racial and ethnic groups. Asthma is more common in children ≥5 years (10%) compared with those <5 years (4%), among Non-Hispanic Black children (16%), American Indian/Alaska Native children (9%), and Puerto Rican children (13%) vs Non-Hispanic white children (6%), and in low-income families (10%) compared with families with incomes ≥250% of the Federal Poverty Level (about 7%).[8,11]

More than half of children with asthma have experienced an asthma exacerbation within the past year, with racial and ethnic disparities in asthma-related emergency department (ED) visits and hospitalizations. The prevalence of asthma exacerbations, ED visits, and hospitalizations is higher among Non-Hispanic Black children (23%) and Hispanic children (16%) than among white children (12%).[11] These racial differences in asthma outcomes may be explained by differences in health-related social needs or social drivers of health.[12,13]

Asthma is a leading cause of school absenteeism. Children who have asthma miss more school days than their peers without asthma. Nearly half of school-aged children with asthma report at least one asthma-related missed school day annually.[11] These absences may be because of a variety of factors, including symptoms, medical appointments, hospitalizations, and sleep disruptions from nighttime respiratory symptoms. Uncontrolled asthma can negatively impact academic performance, with more severe asthma often linked to poorer academic outcomes.[14]

During the COVID-19 pandemic, the epidemiology of asthma in the US underwent notable changes. Health care systems observed reductions in asthma exacerbations, ED visits related to asthma, and asthma-related hospitalizations.[15,16] Multiple factors likely contributed to these decreases, including pandemic response measures such as stay-at-home orders, widespread mask usage, social distancing, as well as a decline in viral infections because of reduced social contact and shifts in patient behaviors.[17] Data on asthma prevalence in the postpandemic period remains limited, with the latest available data from the CDC extending only to 2021.[18]

PATHOPHYSIOLOGY

Asthma is a complex chronic disease characterized by lower airway inflammation, leading to bronchospasm, mucus hypersecretion, airway edema, and long-term airway remodeling, including structural changes such as subepithelial fibrosis, airway smooth muscle hypertrophy, and goblet cell metaplasia that can result in persistent airflow limitation.[19] The development of asthma is influenced by diverse biological mechanisms (endotypes), clinical presentations (phenotypes), and treatment responses (theratypes), shaped by genetic predisposition, epigenetic changes, microbial exposures, and environmental triggers such as pollutants and tobacco smoke.[20–22]

Asthma phenotypes include transient early wheezing, nonatopic wheezing, and atopic wheezing. Transient early wheezing typically resolves by age 3 years and is linked to prematurity, childcare exposure, and tobacco smoke.[23–25] Nonatopic wheezing refers to viral-induced wheezing in early childhood, with respiratory syncytial virus (RSV) often associated with persistent wheezing.[26] Persistent wheezing is defined as ongoing or recurrent wheezing beyond early childhood, frequently linked to airway inflammation or chronic conditions such as asthma. Atopic wheezing is characterized by early allergen sensitization, a family history of atopy, and genetic predisposition. Severe early life illnesses can lead to persistent wheezing across phenotypes.[27]

Allergic asthma is driven by a T-helper (Th) 2-dominant response, with cytokines like interleukin (IL) 4, IL-5, IL-9, and IL-13 inducing immunoglobulin (Ig) E production, recruiting immune cells like mast cells, basophils, and eosinophils into the lungs, and amplifying airway inflammation.[28] These insights have led to biologic therapies targeting specific immune pathways, offering more personalized treatment options.[29] Other mechanisms, including viral-induced Th1 responses and Th17-mediated neutrophilic inflammation, also contribute to inflammation, especially in nonallergic asthma.[29]

Environmental and social factors heavily influence asthma risk and severity. Early life microbial exposure promotes a Th1 response, reducing allergic inflammation, while insufficient exposure favors Th2 dominance and asthma risk, according to the "hygiene hypothesis."[30] Prenatal and postnatal exposure to pollutants, including particulate matter, nitrogen dioxide (NO_2), ozone, and tobacco smoke, disrupts lung development and exacerbates airway inflammation.[21,31–33] Socioeconomic disparities, poor housing, urbanization, chronic stress, and neighborhood violence further worsen asthma outcomes by increasing exposure to triggers and causing immune dysregulation.[34–36]

Additional factors, including household food insecurity and childhood obesity, are associated with increased asthma risk. Food insecurity experienced before kindergarten is linked to higher odds of developing asthma.[37] Obesity in childhood is also associated with a higher prevalence of asthma and may contribute to more severe disease.[38,39]

ASTHMA TRIGGERS

Pediatric asthma management requires recognition of potential asthma triggers and management of exposures to minimize the resultant increased airway inflammation, frequency of symptoms, and acute exacerbations. Effective asthma management involves targeting these triggers across home, school, and community environments. Through interventions, education, and collaboration with community organizations, health care professionals can help mitigate exposures and improve health outcomes for children with asthma.

Viral infections are a frequent cause of asthma exacerbations in children, as respiratory viruses can inflame the airways, intensifying asthma symptoms. Additionally, indoor allergens such as dust mites, animal dander, rodents, mold, and cockroach allergens are widespread and linked to increased asthma morbidity, particularly in urban and low-income settings. Exposure to indoor pollutants, including tobacco smoke and NO_2 from cooking stoves, can lead to the aggravation of asthma and respiratory symptoms. Similarly, outdoor allergens and air pollutants—such as pollen, fine particulate matter ($PM_{2.5}$), which refers to inhalable particles 2.5 μm or less in diameter; wildfire smoke; ground-level ozone; and traffic-related air pollution—play a significant role in exacerbating asthma.[40] The risk of asthma exacerbation from outdoor allergens and air pollutants is especially high in communities with high levels of pollution and limited access to clean air environments.[40] Table 1 lists common asthma triggers and suggested management strategies.

An in-depth review of the home environment is important, as children spend considerable time indoors, where allergens and pollutants are often concentrated. For example, in homes with high levels of indoor allergens or among children sensitized to allergens, implementing targeted interventions such as using HEPA air purifiers, mite-proof bedding covers, and removal of carpeting can reduce allergen levels and improve asthma outcomes. Keeping homes and cars smoke-free, along with the use of dehumidifiers and integrated pest management strategies, can further reduce the presence of asthma triggers. In individuals with sensitization or symptoms related to identified indoor allergens, home-based multicomponent interventions, particularly for low-income families, have shown substantial benefits in reducing hospital visits and improving asthma control.[3,41] Addressing these environmental and social factors through targeted public health interventions and comprehensive environmental health-related policies is crucial to reducing the burden of asthma and improving long-term outcomes.[42,43]

Asthma management also requires a focus on the school setting, where children may be exposed to potential triggers, such as cockroaches, dust, mold, pet allergens on carpets and students' clothing, rodents (including furry classroom pets), as well as pollution from idling buses.[44] Schools located near major roadways may expose children to higher levels of airborne pollutants, which contribute to poorer asthma control and increased ED visits.[45] Climate change can affect the school environment by increasing exposure to extreme heat or cold. Additionally, children with asthma may face increased risks from air pollution—including wildfire smoke, which contains $PM_{2.5}$, a pollutant known to exacerbate asthma symptoms—especially during outdoor activities such as recess and physical education. Educating school staff on managing indoor air quality, monitoring the local air quality index (AQI), and ensuring children with asthma have access to quick-relief medication and a written asthma action plan (AAP) can help mitigate these exposures and promote a safer school environment.

Climate change is a growing concern in pediatric asthma, as it amplifies environmental factors that contribute to asthma exacerbations.[46] Higher temperatures and altered weather patterns increase airborne allergens and pollutants, while more frequent wildfires and severe weather events worsen air quality. These changes disproportionately affect children with asthma, particularly those in urban and low-income areas.[21,47] This further highlights the growing importance of integrating environmental health strategies into asthma management by health care professionals. This comprehensive approach includes educating families on air quality awareness and advocating for cleaner environments, which is crucial in reducing asthma-related health disparities.

CLINICAL ASPECTS OF ASTHMA

Diagnosis

The diagnosis of asthma in children and adolescents is based on the history of recurrent symptoms, evidence of reversible

TABLE 1. Common Asthma Triggers and Management Strategies

Category	Examples	Management Strategies
Infections	• Viral respiratory tract infections • Bacterial pneumonia	• Immunization (eg, COVID-19, influenza, RSV). • Practice hand hygiene. • Treat symptoms promptly.
Indoor allergens	• Animal dander • Cockroach • Dust mites • Mold • Rodents	• Use allergy-proof covers for pillows and mattresses, wash bedding weekly, reduce bedroom clutter, remove carpeting, and limit stuffed toys. Keep pets out of bedrooms. • Limit eating to the dining room and kitchen, promptly wash dishes, and keep counters clean. • Store food in sealed containers. • Repair leaks or damp areas. • Use dehumidifiers to maintain indoor humidity levels between 35–50%. • Consider using air purifiers to improve indoor air quality.
Indoor pollutants	• Air fresheners and incense • E-cigarettes and vaping • Tobacco/Marijuana smoke • Nitrogen dioxide (gas stoves) • Idling cars and buses	• Avoid strong odors: cleaning supplies, perfumes, candles/incense indoors. • Keep house and car smoke-free, including e-cigarettes and marijuana smoke. • Provide advice on quitting and refer the caregiver to a smoking cessation hotline. • Use electric or induction stoves if possible and ensure proper ventilation when cooking. • Work with schools to ensure buses do not idle outside classrooms.
Outdoor allergens	• Grass • Tree and plant pollen • Mold	• Limit outdoor activities during high pollen counts. • Close windows. • Shower and change into clean clothing after spending time outdoors. • Avoid mold sources like damp storage, compost, or raking leaves.
Outdoor Pollutants and Weather Changes	• Air pollution • Vehicle emissions • Wildfire smoke and $PM_{2.5}$ • Extreme heat and cold • Humidity	• Monitor the local air quality index (limit exposure if AQI >100). • Avoid outdoor activities during poor air quality or extreme conditions (heat, cold, high humidity). • Plan outdoor activities away from major air pollution sources, such as highways.
Emotional/stress	• Anxiety/depression • Stress • Strong emotions	• Try to minimize exposure to stressful situations. • Practice relaxation techniques (eg, deep breathing, mindfulness, and meditation). • Seek counseling if needed.
Exercise	• Vigorous physical activity • Cold, dry air with exercise	• Use a short-acting bronchodilator or SMART 5–20 min before activity if prescribed. • Encourage warm-up and cool-down periods. • Use face coverings or exercise indoors if cold, dry air is a trigger. • Maintain good overall asthma control so exercise-induced bronchoconstriction is minimized.

Abbreviations: AQI, Air Quality Index; RSV, respiratory syncytial virus; SMART, single maintenance and reliever therapy.

expiratory airflow limitation (obstruction), and/or response to inhaled beta-agonists and/or inhaled corticosteroids (ICS). Signs and symptoms include cough, wheezing, shortness of breath, exercise intolerance, and/or chest tightness/discomfort. Symptoms vary over time and in intensity. Nighttime or early morning symptoms are common. Asthma triggers such as viral respiratory tract infections, exercise, exposure to allergens or irritants, changes in weather, air pollution, and strong emotions may worsen symptoms.

The initial evaluation should begin with a detailed medical history, including the pattern of symptoms, presence of asthma triggers, and response to previous treatments, if given. Past medical history should include an evaluation for any atopy such as allergic rhinitis, atopic dermatitis, food allergies, prior exacerbations including ED visits and/or hospitalizations, and other medical conditions that may aggravate or mimic symptoms of asthma, such as obesity, gastroesophageal reflux disease (GERD), vocal cord dysfunction, anxiety, or other chronic respiratory conditions like cystic fibrosis or bronchopulmonary dysplasia in certain populations. The environmental history should include factors such as the condition of the home; the presence of carpeting, mold, or mildew; pests; pets; and exposure to pollutants such as tobacco smoke, vaping, or proximity to heavy traffic. The family history should be assessed for asthma or atopy. The social history should include factors that may affect asthma control, such as housing instability, access to medications, transportation barriers to medical care, and psychosocial stressors like family conflict or financial hardship.

The physical examination is often normal, but may reveal signs of atopic conditions, such as allergic conjunctivitis, allergic rhinitis, or atopic dermatitis. In children with obesity —who have a higher prevalence of asthma in a dose-dependent relationship with body mass index (BMI)—physical examination findings may be complicated by overlapping symptoms such as dyspnea or reduced exercise tolerance, which can mimic or mask asthma.[38] Children experiencing an acute asthma exacerbation may have variable symptoms and signs of respiratory distress, including wheezing on lung auscultation and/or a prolonged expiratory phase. Wheezing is a high-pitched sound, usually present during exhalation, that results from lower airway airflow obstruction. Inspiratory wheezing or difficulty is suggestive of vocal cord dysfunction, and not asthma.

A diagnosis of asthma is clinical and is often supported by a patient's improvement in symptoms following appropriate treatment. In children presenting with chronic or recurrent respiratory symptoms consistent with asthma, the diagnosis is established if there is clear clinical improvement and, when available, objective evidence such as improved spirometry after 1 to 3 months of therapy. Once diagnosed, these patients should receive ongoing management aligned with current asthma care guidelines. Figure 1 outlines a basic approach to evaluating a child with respiratory symptoms consistent with asthma.

Diagnostic Testing

Asthma in children and adolescents is a clinical diagnosis, supported by several tools that can aid in both confirming the diagnosis and monitoring disease control and progression over time.

Pulmonary Function Testing (PFT) is a broad term that encompasses a variety of different specialized breathing tests used to assess how well the lungs are functioning, including spirometry, lung volume measurements, diffusion capacity tests, peak flows, methacholine challenge, impulse oscillation, cardiopulmonary exercise testing, and fractional exhaled nitric oxide (FeNO), among others. In most outpatient primary and specialty care settings, spirometry is the most commonly used PFT, as it provides objective measures of airflow obstruction and bronchodilator response. Peak flow measurement and FeNO testing may also be used in some settings, whereas more advanced tests such as lung volumes, diffusion capacity, or bronchoprovocation (eg, methacholine challenge) are typically reserved for specialty centers.

Spirometry. Spirometry is used in both primary and specialty care settings to help support the clinical diagnosis of asthma in patients with suggestive symptoms and to monitor asthma control over time. Although spirometry is most reliably performed in children 6 years of age and older, technically acceptable and reproducible spirometry may be obtained in younger children when performed by experienced pediatric pulmonary function technicians.[48] Spirometry's purpose in asthma management is to document expiratory airflow limitation or obstruction with reversibility. Key parameters measured include forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1), FEV_1/FVC ratio, and forced expiratory flow at 25% to 75% ($FEF_{25–75}$).

In healthy individuals, the FEV_1 and FEV_1/FVC ratio are typically above the lower limit of normal (LLN) value, which is 2 SDs below the calculated reference value for a patient.[49] Patients with asthma may show obstructive lung patterns, with a reduced FEV_1/FVC ratio below the LLN, sometimes with a characteristic concavity in the flow-volume loop. A postbronchodilator increase in FEV_1 of at least 12% or an increase in $FEF_{25–75}$ of over 20% is indicative of a reversible obstructive lung defect supporting a diagnosis of asthma (Figure 2).[4] It should be noted that this definition of bronchodilator response was established in adults. More recent evidence supports using an increase in FEV_1 of over 10% in adults and an increase in FEV_1 of at least 8% of the predicted value in children, which have yet to be updated in current NHLBI or GINA guidelines.[50,51] Spirometry results are often normal in children with asthma, particularly when they are asymptomatic at the time of testing. Asthma remains a clinical diagnosis that incorporates suggestive symptoms, a supportive history, and objective evidence of variable airflow obstruction when present.

Current asthma guidelines recommend obtaining spirometry at the time of diagnosis, and every 1 to 2 years or more frequently if clinically indicated.[2,4] It is essential for primary care professionals to recognize that spirometry can sometimes reveal a greater severity of asthma than clinical assessment alone suggests.[52] Because appropriate therapy reduces asthma morbidity and is tailored to disease severity, spirometry results can help clinicians make more informed decisions about optimal therapy for patients with asthma. Ideally, primary care pediatricians should have access to spirometry in their offices and be trained to perform and interpret it.[53] However, if office-based spirometry is not feasible, patients may need to be referred to a facility or specialist who can provide this testing to support diagnosis and appropriate ongoing monitoring. For a detailed review of spirometry, please refer to the cited articles.[49,54]

FeNO. FeNO is a noninvasive biomarker test that measures the amount of nitric oxide (NO) in a patient's exhaled breath. Nitric oxide is produced by cells in the respiratory tract and is often elevated in patients with airway inflammation, particularly eosinophilic inflammation associated with

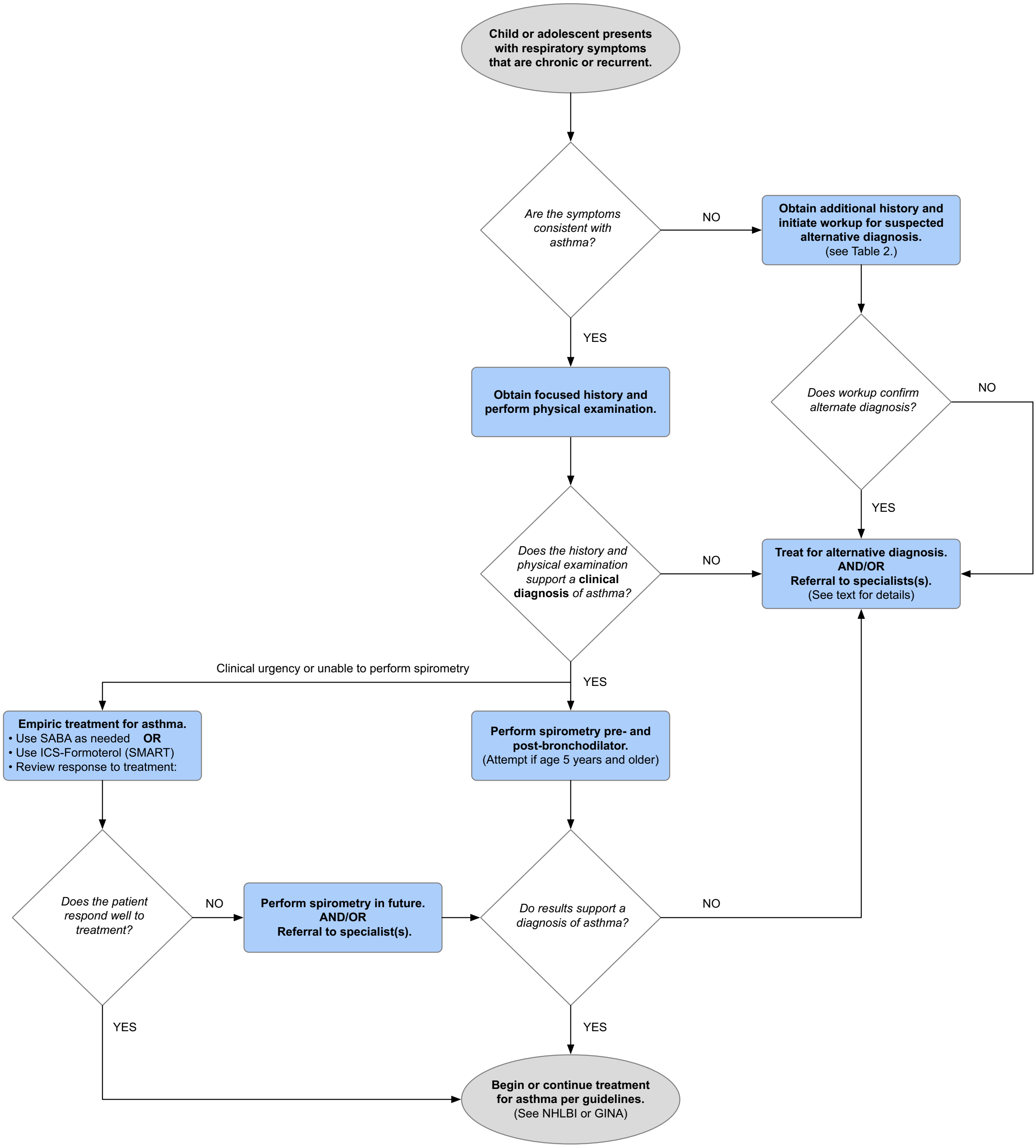

FIGURE 1. Asthma diagnosis flowchart.

allergic (type 2) asthma. FeNO results can also be elevated in nonasthma conditions (eg, allergic rhinitis, atopic dermatitis), and are not elevated in some types of asthma (eg, neutrophilic asthma, asthma with obesity).[4] In addition, FeNO levels vary by multiple factors, including gender, age, and time of day (higher later in the day than in the morning).[4]

Measurement of FeNO can be done in an office setting. The NHLBI asthma guidelines recommend its use in patients 5 years and older whose diagnosis cannot be confirmed by history, physical examination, and spirometry with bronchodilator administration.[2] FeNO must be performed before spirometry to avoid "wash out" of NO during testing. Elevated FeNO levels can support a diagnosis of eosinophilic airway inflammation, but are not specific to asthma and may be elevated in other conditions, such as allergic rhinitis or atopic dermatitis.[4] A key barrier to using FeNO is the lack

Spirometry								
Parameter	Units	**Ref**	**LLN**	**Pre**	**% Ref**	**Post**	**% Ref**	**% Chg**
FVC	L	4.59	3.81	**4.78**	104	**4.92**	107	3
FEV_1	L	3.98	3.28	**3.79**	95	**4.29**	108	13
FEV_1/FVC	%	87	77	**79**	91	**87**	100	10
FEF_{25-75}	L/s	4.35	2.95	**3.32**	76	**4.96**	114	49
PEFR	L/s	8.26	6.07	**9.90**	120	**9.22**	112	-7
FET	sec			**3.67**		**3.63**		-1

Flow Volume & Volume Time

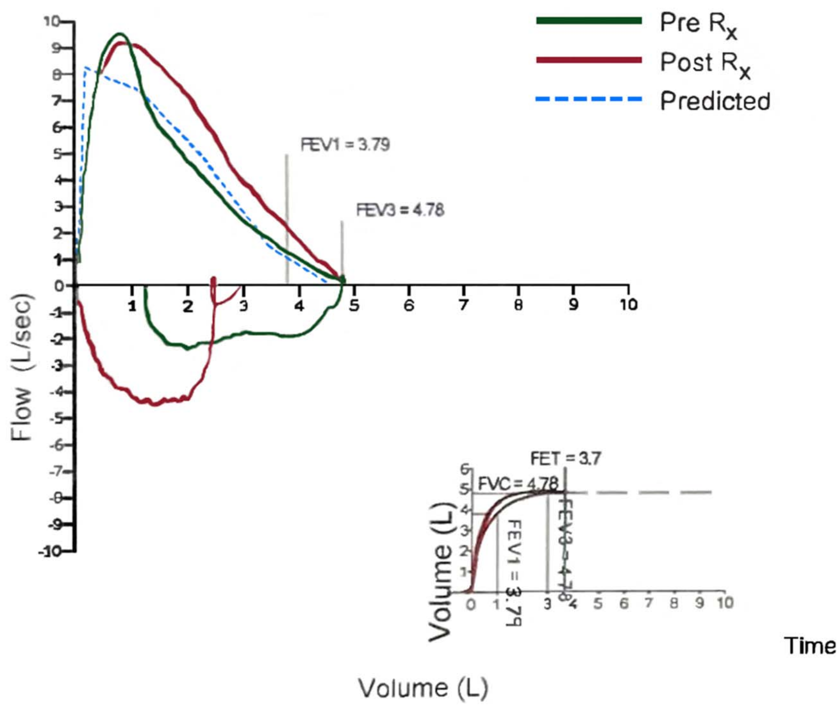

FIGURE 2. Spirometry and Flow-Volume Loop. Spirometry in a 15-year-old adolescent with exertional dyspnea and chest tightness. Forced expiration showed no obstructive ventilatory defect (FEV_1/FVC ratio of 79%, above the LLN [77%]). However, the flow-volume loop demonstrated reduced expiratory flow at low lung volumes, suggesting small airway involvement. Following bronchodilator administration, clinically significant improvements were noted in FEV_1 (13% increase) and FEF_{25-75} (49% increase). The patient was advised to use a bronchodilator 10 to 15 minutes before vigorous physical activity.

of insurance reimbursement. FeNO is primarily used in asthma specialty settings, where it can help guide treatment decisions, especially in patients with more severe or difficult-to-control asthma.[55]

Peak Flows. Peak expiratory flow (PEF) readings are generally not recommended for routine asthma management in children because of issues with accuracy, effort dependence, and limited diagnostic value. PEF measurements can be highly variable, are easily influenced by suboptimal technique or intentional underperformance, and are less reliable than spirometry, which is the preferred objective measure when available.[2,4] Peak flow monitoring is typically only recommended when spirometry is unavailable. When used to aid in asthma diagnosis, a diurnal variability in peak flow over 13% may indicate asthma in children.[56] Patients can record their peak flow readings at home, usually twice daily, taking the best of 3 attempts each time. Diurnal variability is calculated as the difference between the highest and lowest readings, divided by the average of these 2 values. For example, if the highest is 200 and the lowest is 170, the normal diurnal variability that day is 15%.

Methacholine Challenge. Methacholine is a neurotransmitter that acts on receptors in the airway smooth muscles, resulting in constriction. In the asthma subspecialty clinic setting, the methacholine challenge test is useful for ruling out asthma in patients whose diagnosis has not been

TABLE 2. Differential Diagnosis of Asthma

Diagnosis	Age	Clinical Findings and Key Features	Diagnostic Tests and Next Steps
ABPA	Any	• Intermittent fevers with chronic cough. • Predisposing conditions include asthma and cystic fibrosis.	• Referral to specialist. • CXR, HRCT. • Aspergillus IgE and IgG.
Allergic rhinitis	Any	• May cause recurrent coughing and/or throat clearing. • Other symptoms that distinguish from asthma.	• Clinical diagnosis. • Empiric treatment.
Bronchiectasis	Any	• Chronic wet cough (4 weeks).[3] • Recurrent infections (eg, pneumonia). • Dyspnea, especially on exertion.	• Referral to specialist. • Bronchoscopy. • HRCT.
Bronchiolitis	<24 mos	• Acute onset symptoms with viral illness. • No response to SABA.	• Clinical diagnosis.
BPD	<24 mos	• History of prematurity. • Symptoms are often present since birth.	• Clinical diagnosis.
Cystic fibrosis	Any	• Abnormal newborn screen. • Respiratory symptoms and failure to thrive.	• Referral to specialist. • Sweat chloride, genetic testing.
Food allergy	Any	• Wheezing is associated with food ingestion. • May have other signs of food allergy (eg, anaphylaxis, lip swelling, vomiting, hives).	• Allergy testing. • Referral to specialist. • Spirometry.
Foreign body aspiration	Any (<4y more common)	• Acute onset of symptoms after choking. • Focal wheezing or decreased air entry.	• CXR (Pulmonary artery and lateral). • Bronchoscopy.
GERD/chronic aspiration	Any	• Recurrent bouts of respiratory problems. • Review symptom pattern and risk factors (eg, prematurity, diet, feeding issues, neurologic impairment).	• Referral to specialist. • Endoscopy, pH probe. • Swallowing evaluation.
Habit cough/Tic cough	School age or older	• Dry, repetitive cough. • Absent during sleep. • May worsen with stress or attention.	• Clinical diagnosis. • Consider reassurance and behavioral therapy. • Rule out other causes if indicated.
Heart failure	Any	• Fever (eg, viral myocarditis), missed congenital heart disease, failure to thrive. • Symptoms worsen with feeding or lying down. • Murmur, poor central pulses, hepatomegaly, crackles.	• CXR, ECG. • Admit to hospital. • Consult specialist. • Echocardiography.
Immunodeficiency	Any	• Recurrent episodes of bacterial pneumonia.	• Referral to specialist.
Mass effect (eg, vascular anomaly or mediastinal tumor)	Any	• Symptoms may vary with position. • Poor response to standard asthma treatments.	• Consult specialist. • Bronchoscopy/chest CT.
Neurogenic/Neurosensory cough	School age or older	• Persistent dry cough lasting weeks to months. • Often described as a tickle or urge to cough. • May be triggered by coughing, laughing, or cold air. • No wheezing or response to asthma therapy.	• Clinical diagnosis. • Consider referral to specialist if concerning features.
Panic attacks/anxiety	School age or older	• Absence of wheezing. • No response to SABA.	• Clinical diagnosis. • Normal spirometry.
Postviral cough	Any	• Cough lasting up to 8 weeks following a viral URI. • Usually improving over time. • No signs of infections or other pathology. • Normal examination between episodes.	• Clinical diagnosis. • Symptomatic treatment. • Reassess if cough persists beyond 8 weeks.
PBB	Any (<5y more common)	• Chronic wet cough (4 weeks).[3] • No evidence of an alternative diagnosis.	• CXR (often normal). • Normal spirometry.
Tracheobronchomalacia	<24 mos	• Symptoms may vary with position. • No response to standard asthma treatments.	• Referral to specialist. • Laryngoscopy.
Viral-induced wheeze	Any (<4 y more common)	• Wheezing only with viral illness. • Usually resolves by age 4–6 y.	• Spirometry if frequent or severe and age-appropriate.

Continued

TABLE 2. Differential Diagnosis of Asthma (Continued)

Diagnosis	Age	Clinical Findings and Key Features	Diagnostic Tests and Next Steps
Vocal cord dysfunction	Adolescent or older	• Acute onset symptoms within minutes of exercise. • Symptoms quickly resolve with rest. • Wheezing or breathlessness on inspiration. • Poor response to standard asthma treatments.	• Spirometry may show a flattened inspiratory loop. • Referral to specialist. • Laryngoscopy.

Abbreviations: ABPA, allergic bronchopulmonary aspergillosis; BPD, Bronchopulmonary dysplasia; CT, computed tomography; CXR, chest radiography; ECG, electrocardiogram; GERD, gastroesophageal reflux disease; HRCT, high-resolution CT; IgE, immunoglobulin E; IgG, immunoglobulin G; PBB, protracted bacterial bronchitis; SABA, short-acting beta agonist; URI, upper respiratory tract infection.

confirmed by spirometry. Health care professionals should be aware that the test may provoke significant asthma symptoms, so the risks and benefits should be carefully considered. A 20% drop in FEV_1 from baseline is considered a positive response.[57]

Cardiopulmonary Exercise Testing (CPET). For children experiencing exercise-induced symptoms, a CPET can be performed using a treadmill or exercise bike. FEV_1 is measured before and after a standardized exercise period. This test is particularly useful for patients who do not meet typical asthma criteria or are suspected to have exercise-induced laryngeal obstruction with symptoms mimicking asthma. A drop in FEV_1 of 10% to 12% is considered a positive result for exercise-induced bronchospasm.[58]

Impulse Oscillation. This technique uses sound waves, transmitted into the lungs during normal tidal volume breathing, to measure airway resistance and conductance. It is suitable for patients as young as 4 years and has shown improvement in airway measurements following a course of ICS in young children with asthma.[59] This test is typically available only in specialty practices and is not commonly used in primary care settings.

Chest Radiography (CXR). Routine CXR is not recommended for the diagnosis or management of asthma in children. CXRs are generally unnecessary for managing asthma exacerbations in primary or acute care settings, as they rarely alter the course of treatment. However, CXR may be appropriate in patients with atypical signs or symptoms, such as fever, focal lung findings on examination, suspicion for pneumonia, foreign body aspiration, pneumothorax, and/or failure to improve with standard asthma therapy. In these cases, a CXR can help identify alternative or additional diagnoses that may require a change in management.

Additional Diagnostic Tools

In many instances, diagnosing asthma is straightforward. However, challenges can arise, particularly in cases involving atypical symptoms, very young children, or those lacking identifiable risk factors. Early life viral infections, especially RSV, rhinovirus, and human metapneumovirus, associated with wheezing, may be the first signs of asthma in young children. Children under 5 years of age often cannot provide the coordinated effort necessary for reliable spirometry. To assist in these situations, health care professionals can use various clinical tools, including the Asthma Predictive Index, modified Asthma Predictive Index, and the Pediatric Asthma Risk Score.[60–62] Importantly, the utility of these tools depends on an initial clinical suspicion of asthma.

The Asthma Predictive Index is a clinical tool that can be used to help diagnose asthma in children under at least 3 years of age. The index uses a combination of major criteria (parental asthma or atopic dermatitis in the child) and minor criteria (allergic rhinitis in the child, wheezing outside of colds, or blood eosinophil level ≥4%). A diagnosis of asthma can be made if the child has a history of wheezing and meets one of 2 major criteria and/or 2 of 3 minor criteria. The modified Asthma Predictive Index includes an additional major criterion of allergic sensitization to aeroallergens and an additional minor criterion of allergic sensitization to milk, egg, or peanuts.

The Pediatric Asthma Risk Score is an asthma screening tool published in 2019 that allows health care professionals to calculate a patient's risk of developing asthma based on criteria similar to those in previous indices, with additional factors such as early wheezing, Black/African ancestry, and skin test positivity.[62,63] The tool can be downloaded to a smart device from the iOS or Google Play app stores, and it is also available online at https://pars.research.cchmc.org/.

Differential Diagnosis

It is essential for the health care professional to recognize that many other conditions besides asthma may present with chronic cough or wheezing. A broad differential diagnosis should be considered for any child who presents with an initial episode of wheezing, asthma that is difficult to control, or if there is little or no relief of symptoms with inhaled beta-agonists. Table 2 lists common conditions mimicking asthma.

Summary

- Asthma is one of the most common chronic diseases in children and is frequently encountered by pediatric health care professionals.[1–5] (Level A: Based on strong evidence)
- Diagnosis is clinical, based on characteristic signs and symptoms observed over time, rather than a single episode of wheezing.[2–4] (Level A: Based on strong evidence)
- Children with asthma are often exposed to substantial environmental triggers and social determinants that can complicate management.[13,33,35,36,44,45] (Level B: Based on moderate research evidence)
- Patients with atypical presentations, diagnostic uncertainty, or poor response to standard treatment should be further evaluated or referred to a pediatric pulmonologist or asthma specialist.[2–4] (Level C: Based on some research evidence and consensus among experts)

Take the quiz! Scan this QR code to take the quiz, access the references and view and save images and tables (available January 1, 2026).

PIR QUIZ

1. A 4-year-old biracial boy is brought by his parents for a routine well examination at a rural new clinic. In review of his history, he has frequent wheezing, especially when ill. He has used albuterol in the past, which has been helpful. The nurse informs you that the family answered "yes" to the clinic's routine food insecurity questions. They answered "no" to concerns for violence in the home or local community. Which of the following social factors most increases the risk of developing asthma at this patient's age?
   - A. Food insecurity.
   - B. Local community.
   - C. Racial group.
   - D. Rural location.
2. A 4-year-old boy is hospitalized with hypoxia and dehydration during an acute illness with influenza. This is his second hospitalization for similar symptoms this year. His home medications include cetirizine daily in the fall and intermittent use of topical hydrocortisone. On physical examination, he has a temperature of 37°C, heart rate of 140 bpm, respiratory rate of 40/minute, and requires 2 L/min oxygen via nasal canula to maintain saturations greater than 88%. His lung examination has a prolonged expiratory phase and diminished breath sounds. Which of the following is the most likely diagnosis in this patient?
   - A. Asthma.
   - B. Gastroesophageal reflux disease.
   - C. Streptococcus pneumoniae pneumonia.
   - D. Vocal cord dysfunction.
3. A 10-year-old girl is brought to the clinic by her parents with a history of frequent nighttime cough. Further history is consistent with a harsh cough several nights per week, especially with viral illnesses, during the fall harvest time, and when camping. She has a history of eczema that is well-controlled with topical treatments. She has tried a sibling's albuterol while camping a few weeks ago, and it helped with the cough for a few hours. Today, on physical examination, she is well-appearing with normal vital signs and normal lung sounds. Which of the following diagnostic studies is recommended at this time?
   - A. Chest radiography.
   - B. FeNO.
   - C. Peak expiratory flow.
   - D. Spirometry.

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MOC

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4. A 12-year-old boy is brought to the clinic by his parents for a sports clearance physical examination to begin soccer this year. He is overall healthy but does have "noisy" breathing and gets "winded" during exercise. They describe the noise as a high-pitched inspiratory sound that improves with rest. When he was a child, he required the use of albuterol intermittently with illnesses. He was born term and has no other past medical concerns. On physical examination, he is well-appearing with normal vital signs and normal lung sounds. Which of the following is the next best diagnostic study to obtain in this patient?

   A. Cardiopulmonary exercise testing.
   B. Chest radiography.
   C. Impulse oscillation.
   D. Spirometry.

5. A 2-year-old is brought to the clinic by his parents for a follow-up appointment from acute care. He was seen there for wheezing, and this was his third acute care visit for the same concern. He has a history of eczema that is well-controlled. He has been taking albuterol every 4 hours as needed, with his last dose 6 hours ago. On physical examination, the patient has normal vital signs today. On lung examination, he has an end-expiratory wheeze with no distress. Which of the following is the best next step in diagnosis for this patient?

   A. Asthma Predictive Index.
   B. Chest radiography.
   C. Methacholine challenge.
   D. Spirometry.