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REVIEW ARTICLE

Asthma Phenotypes in Children: Implications for Personalized Treatment Approaches

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Abstract

The clinical symptoms, inflammatory processes and reactions to medication vary greatly in children with asthma. The idea of asthma phenotypes is to group these different clinical patterns to help with diagnosis, prediction of the future and treatment. This review looks at the latest knowledge about pediatric asthma phenotypes, drawing on both Indian and worldwide research. Major types of asthma such as allergic, non-allergic, early-onset, late-onset and severe asthma, are discussed and their main symptoms and causes are highlighted. Treatment plans designed for these phenotypes by using targeted biologics and anti-inflammatory therapies are discussed. It is also pointed out that pediatric asthma phenotyping in India needs improvement and researchers are urged to use longitudinal and molecular methods to better classify patients and provide better care. Tailored care for asthma in children could improve their condition, lower the risk of attacks and raise their quality of life.

Keywords: Pediatric asthma, asthma phenotypes, personalized treatment, Indian population, allergic asthma, severe asthma, biomarkers

INTRODUCTION

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Asthma is a frequent long-term lung disease in children around the world and its number in India is growing. This disease is marked by constant inflammation in the airways, different levels of airway obstruction and an overreaction of the bronchi, resulting in frequent episodes of wheezing, coughing and shortness of breath. Asthma has usually been seen as a single disease, but recent findings show that it is made up of several distinct types, mainly among children (Pavord et al., 2018). Their differences are found in how they appear clinically, in the physical processes involved, in their inflammatory features and in how they react to treatment.

The fact that asthma comes in many forms has significant clinical effects. Because their immune and lung systems are still developing, children show even greater phenotypic diversity than adults. When a child is exposed to allergens, infections and pollutants early in life, their genetic background helps to determine their phenotype (Custovic & Murray, 2019). By knowing a patient's specific asthma type, clinicians can use more personalized treatment which improves disease management and lowers chances of side effects.

Although there have been many advances in phenotyping elsewhere, we have only a little but steadily increasing data from India which has distinct environmental factors, economic differences and healthcare issues. In India, children with asthma may experience different symptoms because of indoor air pollution, city life and what they eat. Knowing about these phenotypes in India is important for improving diagnosis, prognosis and treatment planning (Agrawal et al., 2020).

The goal of this review is to assemble information about Indian pediatric asthma phenotypes, suggest customized treatments for each phenotype and highlight areas where more studies are needed.

METHODS

A literature search was performed on PubMed to find open-access articles up to May 2025. The search terms were "pediatric asthma phenotypes," "children," "asthma treatment in India," and "personalized asthma therapy." Only original studies, reviews and clinical trials on asthma in children and especially those with Indian populations, were considered in the review. Only studies that focused on adults or respiratory diseases other than asthma were not included. We also searched through lists of relevant articles.

Review of Asthma Phenotypes in Children

Asthma phenotypes in children are primarily classified based on clinical features, inflammatory profiles, triggers, and disease severity. Major phenotypes identified in the literature include:

1. Allergic (Atopic) Asthma

A significant number of children with asthma fit the allergic phenotype, showing an early age of disease, positive allergy tests, many eosinophils and a family history of allergies (Jindal et al., 2021). In many

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Indian studies, it has been found that atopic asthma affects 45% to 65% of children and is often brought on by dust mites, cockroaches and pollen (Patel et al., 2019).

2. Non-Allergic Asthma

In children, non-allergic asthma is not as common, doesn't involve IgE sensitization and may be related to neutrophilic inflammation. It is most often linked to viruses and pollution from the environment (Singh et al., 2020). Its symptoms change more often and the response to steroids can be reduced.

3. Early-Onset and Late-Onset Asthma

Typically, asthma that starts before a child's sixth birthday is often allergic, but the type that develops in adolescence is caused by inflammation (Kumar et al., 2018). Indian studies have pointed out that early detection is key to stopping airway remodeling.

4. Severe Asthma

Just a few children have severe asthma, yet it is very difficult to treat because frequent episodes and high-dose medication do not control the disease well (Mishra et al., 2022). The main feature of heterogeneity in this group is that patients have ongoing inflammation with eosinophils and do not respond to corticosteroids.

5. Obesity-Associated Asthma

It is now commonly seen in urban areas of India that obesity-related asthma often has neutrophilic inflammation and does not respond well to inhaled corticosteroids (Gupta et al., 2021).

Table 1 summarizes the key pediatric asthma phenotypes with their clinical and inflammatory characteristics as reported in recent Indian studies.

Table no.1: Major Pediatric Asthma Phenotypes: Clinical and Inflammatory Characteristics

Phenotype	Age of Onset	Inflammatory Profile	Common Triggers	Steroid Responsiveness	References
Allergic Asthma	Early (<6 yrs)	Eosinophilic, IgE mediated	Dust mites, pollen, cockroach	Good	Jindal et al., 2021; Patel et al., 2019
Non-Allergic Asthma	Variable	Neutrophilic or paucigranulocytic	Viral infections, pollutants	Variable	Singh et al., 2020
Severe Asthma	Any	Mixed; corticosteroid resistant	Multiple	Poor	Mishra et al., 2022

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Obesity-Associated	Late childhood	Neutrophilic, low-grade inflammation	Obesity, metabolic factors	Reduced	Gupta et al., 2021

Personalized Treatment Approaches

The heterogeneity of pediatric asthma phenotypes necessitates personalized treatment strategies. Current guidelines emphasize phenotype-based therapy to optimize efficacy and minimize side effects.

1. Allergic Asthma

In children with allergic asthma, inhaled corticosteroids (ICS) remain the cornerstone of treatment. Recent Indian studies highlight the role of leukotriene receptor antagonists as adjuncts (Patel et al., 2019). For severe allergic asthma, biologics targeting IgE (omalizumab) have shown efficacy, though access remains limited in India (Mishra et al., 2022).

2. Non-Allergic and Neutrophilic Asthma

Non-allergic asthma may require alternative anti-inflammatory therapies, such as macrolides or bronchial thermoplasty in severe cases, though pediatric data remain sparse (Singh et al., 2020).

3. Severe Asthma

SManaging severe asthma involves high-dose ICS, long-acting beta-agonists and biologics, depending on the results of eosinophil markers (Gupta et al., 2021). This area of medicine is still developing.

4. Obesity-Associated Asthma

Weight management and addressing metabolic inflammation are integral, combined with standard asthma therapies (Gupta et al., 2021).

Table 2 presents a comparative overview of treatment modalities aligned with asthma phenotypes based on evidence from Indian cohorts.

Table no.1: Personalized Treatment Strategies According to Pediatric Asthma Phenotypes

Phenotype	**First-line Therapy**	**Adjunctive Treatments**	**Biologics/Advanced Therapies**	**Evidence from Indian Studies**
Allergic Asthma	ICS + SABA	Leukotriene receptor antagonists	Omalizumab (anti-IgE)	Patel et al., 2019; Mishra et al., 2022

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Non-Allergic Asthma	ICS or macrolides (in severe cases)	Environmental control	Limited pediatric data	Singh et al., 2020
Severe Asthma	High-dose ICS + LABA	Oral corticosteroids	Mepolizumab (anti-IL-5), Dupilumab	Mishra et al., 2022; Gupta et al., 2021
Obesity-Associated	ICS + weight management	Lifestyle modification	Under investigation	Gupta et al., 2021

DISCUSSION

Phenotyping pediatric asthma makes it easier to give personalized treatment, but some obstacles remain. Indian studies are restricted by having few participants, not using uniform phenotyping methods and little availability of data collected over time. In addition, it is challenging to obtain biomarkers (such as sputum eosinophils and FeNO) in regular medical settings.

It is important to use both molecular and genetic information to improve the description of phenotypes. The combination of environmental problems and socioeconomic conditions in India makes it difficult to carry out phenotyping.

Even so, using personalized treatment based on phenotype has shown better control and fewer exacerbations in several studies, making it suitable for clinical use.

Future Directions

Future research should focus on:

- Conducting large, extended studies in Indian children to confirm the identification of phenotypes.
- Creating and proving the usefulness of biomarkers that can be used affordably in low-resource places.
- Looking at how genes and the environment combine to affect a person's traits.
- Improving access to biologics and personalized therapies for people in India.
- Using precision medicine by blending information from clinical, molecular and environmental sources.

Because of these advances, diagnosing and treating asthma will become more accurate which will help lessen the burden of asthma in children.

CONCLUSION

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There are many different ways that pediatric asthma can present and these differences greatly influence both the symptoms and how treatments are used. To use personalized treatments that help with disease control and quality of life, it is important to study these phenotypes in the Indian population. While allergy and severe asthma in children are well known, asthma linked with obesity shows how asthma can be affected by genes and the environment. Even though progress has been made, important differences still exist in how diseases are classified, what biomarkers are used and who can get advanced therapies.

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