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Racial Disparities in Pediatric Asthma: A Review of the Literature

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Abstract The burden of asthma disproportionately affects children living in economically disadvantaged urban communities. The relationships between ethnicity, genetic differences, lower socioeconomic status, poor medication adherence, greater exposure to environmental triggers, and absence of regular asthma care all contribute to this disparity. This review aims to identify and discuss recent studies on additional factors that may also impact to pediatric asthma disparity. The body of work examined in this review suggests that these disparities are the result of gene–environment interactions, vitamin D metabolism, socioeconomic status, urban environment, healthcare setting, and associated health beliefs.

Keywords Asthma · Pediatrics · Pulmonology · Disparity · Disparities · Race · Racial · Ethnic · Ethnicity · Urban · Rural · Inner city · Children · Adherence · Minority · Socioeconomic · African American · Hispanic

Introduction

Asthma affects people of all races, ages, and ethnic groups, but poor, inner-city minorities experience disproportionate rates of asthma morbidity and mortality. For example, African Americans visit emergency departments, are hospitalized, and experience death due to asthma at rates three times higher than rates for white Americans [1]. Some postulate that a disproportionately increased respiratory morbidity exists among inner-city minority populations, due in part to an underdiagnosis of disease, underestimation of morbidity by patients and health care professionals, and lack of access to quality medical care. This review aims to identify and discuss recent studies on additional factors that may contribute to pediatric asthma disparity. Specifically, this review examines gene–environment interactions; the urban environment; communication and symptom perception; socioeconomic status (SES); health care setting; and the role of nutrition, particularly vitamin D, in pediatric asthma disparity.

Genetics and Social Environment Interactions

Pediatric asthma disparity may be attributed to variations in genes and their interaction with the environment. A recent study of children with asthma examined the effects of the social environment on genetic processes [2]. The study found that genetic pathways that are involved in regulating inflammation and catecholamine signaling varied by SES. Children of low SES overexpressed genes that regulated various inflammatory processes such as chemokine activity, stress responses, and wound responses. In contrast, the high SES group overexpressed genes that may be involved in containing damage caused by inflammation. The authors hypothesized that SES has an effect on children's interpretation of their social world that alters neuroendocrine and inflammatory signaling processes. They found that children in the low SES group were more likely to perceive threat in ambiguous situations that activated these processes. These

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findings are significant, as inflammatory and catecholamine signaling pathways are primary targets for asthma medications. This study demonstrated that these pathways are affected by low SES, indicating that the social environment may play a role in the efficacy of current asthma therapy [2].

Role of the Urban Environment

The urban environment also plays a significant role in pediatric asthma disparity. Homes in urban areas frequently contain levels of pollutants that contribute to increased asthma morbidity. Common pollutants in the urban environment include environmental tobacco smoke; nitrogen dioxide; ozone and particulate matter; and indoor allergens such as cockroach, molds, house dust mites, and cat and dog dander. A recent study by Priftis et al. [3] examined asthma symptoms and airway narrowing in children living in an urban versus a rural environment. According to the study, inner-city children had more episodes of acute respiratory infection than children living in rural areas. Additionally, children living in rural environments were less sensitized to inhaled allergens compared with those living in urban areas, and more urban children in the study were sensitized to pets despite the fact that children raised in rural areas are more likely to be exposed to cats and dogs. The authors proposed that these effects may result from overcrowding, poor nutrition and sanitation, indoor air pollution, and microbial exposure and close animal contact (both of which provide a protective effect on sensitization) [3]. Thus, rural protection and urban pollution both could be mitigating the difference in sensitization among children living in urban versus rural areas.

The authors also discussed the nutritional habits of those living in urban environments. In these environments, there is a trend toward increased consumption of snacks, fast food, and sweetened beverages, whereas regular consumption of fresh fruits, vegetables, and fish rich in omega-3 fatty acids may have a protective effect in the development of asthma. These foods are not typically found in the diet of children living in urban areas. The authors also documented an association between traffic-related air pollution and asthma that is most prevalent among urban children. This article supports previous evidence that chronic stress can shape biologic responses early in life that may enhance the effects of air pollution on common physiologic systems [3].

Long-term exposure of healthy children and adolescents to urban environments has been associated with an increased risk of reduced lung function. The authors cited three studies in which long-term exposure to pollutants was associated with deficits in forced expiratory volume in 1 s (FEV_1) and forced vital capacity (FVC). Additional studies demonstrated an association between pollution and poor lung growth. A study conducted in Greece found an independent relationship between decreased forced expiratory flow at 50% and urban living. The authors concluded that residence in a polluted urban environment may result in subclinical small airway disease [3].

The type and quality of housing in the urban environment may also play a role in pediatric asthma disparity. A recent study by Northridge et al. [4] demonstrated a relationship between housing type and childhood asthma even after adjusting for individual- and community-level demographic and economic factors. Residents of private family homes had the lowest odds of current asthma when compared with residents of public housing. In this study of 4853 children, minority children—specifically African Americans and Puerto Ricans—made up the majority of the residents living in public housing. Whites, Asians, and more affluent families were more likely to live in private family housing. More residents of public housing reported the presence of cockroaches and were less likely to use an air conditioner. Residents of mixed-use buildings commonly reported exposure to mold and rats. Living in homes with cockroaches or rats was associated with having asthma, and children living in homes with water leaks were 1.54 times more likely to have current asthma compared with children living without water leaks. Variations in housing quality that are related to difference in SES may account for the asthma disparities within these communities [4].

A Chicago study demonstrated a higher prevalence of poor respiratory health that was associated with higher housing stressors for six of the eight outcomes that were measured [5]. These included housing security, mobility, comfort, safety, finances, dynamic household membership, and relationships with neighbors and landlords. The authors hypothesized that these stressors affect the following outcomes: child and parental general health; controllability of the child's asthma; exercise intolerance; waking at night; school absences; frequency of rescue medication use; and the number of unplanned visits to the emergency department, physician's office, or clinic. Covariates that were identified as potential confounders in this study included parental education, marital status, birth, race/ethnicity, home ownership, housing type, overcrowding, and Temporary Assistance to Needy Families receipt. The study demonstrated that an increased number of stressors and difficulty managing these stressors were associated with higher risks and rates for most of the outcomes measured. The authors of this study posited that stressors may compete with a parent's time resources and motivation to manage a child's asthma. They also cited evidence in which the parent's stress may produce stress responses in children that lead to emotional coping strategies that are associated with lower perceived control, rescue medication overuse, controller medication underuse, and increased emergency care and hospitalization, as well as strategies that may be even more harmful (e.g., smoking, overeating, and sedentary lifestyle). This study further adds to the growing evidence that the social environment may contribute to asthma burden in urban areas [5].

Another study by these authors examined parental perception of neighborhood stressors and their association with general and respiratory health in low-income families [6]. Specifically, parental perceptions on two aspects of neighborhoods—collective efficacy and physical/social order—were examined. The results of this study indicate that more negative neighborhood perceptions tend to be associated with higher risk of undesirable general and respiratory health outcomes [6].

Symptom Perception

The Blowing the Whistle study assessed 35 African American adolescents and their caregivers' perception of what was termed *wheeze* [7]. The study determined that few respondents (5.8%) referred to wheeze as a whistling sound despite this being central to most clinical and epidemiologic definitions. Respondents viewed a video clip of an adolescent wheezing and were asked to describe the adolescent's breathing. Sixty-two percent of caregivers and 41% of adolescents also described other symptoms in addition to wheeze, such as shortness of breath, cough, or an "asthma attack." Twenty-one percent of caregivers and 11.8% of adolescents characterized wheeze as something that is heard and felt [7].

The findings suggest that adolescents and caregivers use the term wheeze differently, whether in place of or in combination with chest tightness, cough, or shortness of breath. The authors proposed that some families likely use the term wheeze to refer to a range of asthma symptoms [8]. The recognition of different asthma symptoms is important for effective diagnosis and treatment of asthma. The accurate recognition of symptoms by patients is important in enabling physicians to diagnose and manage their patients with asthma. Understanding the patient's perception of symptoms may facilitate more effective communication between providers and patients, thereby enhancing diagnosis and treatment of asthma.

Provider and Caregiver Communication

Studies have shown that caregiver and provider communication can have an impact on asthma outcomes [8]. A recent intervention study on the influence of caregiver and provider communication on symptom days and medication use in inner-city children with asthma demonstrated that caregivers are reluctant to communicate their asthma concerns with their provider. Although the intervention had no impact on decreasing symptom days, the study did find a moderate association between caregiver and provider communication and appropriate controller medication use, and highlighted other factors associated with effective communication. Anecdotal reports indicated that almost half of the families failed to bring their communication cue cards to the nurse/health educator visit despite multiple reminders, and also demonstrated significantly low adherence to clinical visits. Sixty percent of the intervention group had one visit with the clinician, and only 27% had two clinician visits, even after reminders were established in the intervention. The study also noted that most children and parents in the intervention group required prompting from the nurse/health educator to communicate symptoms. Furthermore, non-asthma diagnoses, such as obesity, behavior problems, and poor dental health, dominated many clinic visits, limiting the discussion of asthma concerns [9].

Adherence

Adherence to clinical visits and asthma therapy is paramount in the control of asthma. Adherence to asthma control therapy resulted in decreased health care utilization in a study by Crocker et al. [10] that examined racial and ethnic disparities in asthma medication use and health care utilization. In this study of 1485 children, significantly fewer African American and Hispanic children reported using inhaled corticosteroids (ICS) in the past 3 months compared with white children. More African American children (26%) and Hispanic children (19%) reported receiving a daily dose of short-acting β-agonists compared with white children (12%), and African American children were twice as likely to have had at least one hospitalization or emergency department visit due to asthma in the past year. Emergency department visits were positively correlated with short-acting β-agonist use and were negatively correlated with ICS use. In summary, racial and ethnic minority groups had the highest proportion of children with one or more asthma-related emergency department visits, the highest proportion of children with daily use of short-acting β-agonists, and the lowest proportion of children using ICS [10].

A recent study by Celano et al. [11•] examined adherence and its predictors in low-income African American children with persistent asthma. This study measured adherence, observed metered-dose inhaler (MDI)/spacer technique, and explored exposure to environmental tobacco smoke. The mean daily adherence rate for fluticasone MDI was 59%, and 70% for montelukast. The mean daily adherence rate was 59% for patients who were prescribed both medications. Medication adherence did not correlate with MDI/spacer technique or with environmental tobacco smoke exposure as measured by cotinine/creatinine ratio [11•].

The study also assessed other predictors of adherence. Older age at birth of the first child and receipt of Medicaid/State Children's Health Insurance Program benefits were associated with higher fluticasone mean daily adherence. The study also found that lower levels of caregiver depressive symptoms were marginally associated with greater fluticasone/montelukast adherence. However, children with higher levels of depressive symptoms exhibited poor MDI technique. Environmental tobacco smoke exposure was only associated with poorer caregiver asthma knowledge, not adherence. Interestingly, the most consistent predictor of adherence was asthma knowledge. Asthma knowledge at the initial visit accounted for a significant increase in adherence at the final visit [11•].

Medication beliefs by minority groups may play a role in medication adherence and asthma. Concern about the safety of daily ICS therapy and development of ICS tolerance with regular use was also a predictor of lower adherence. Some postulate that medication beliefs may mediate the relationship between minority status and adherence to therapy. In a study by Le et al. [12], minority patients had nearly sevenfold higher adjusted odds of endorsing negative beliefs about their asthma medications.

Otuski et al. [13] conducted a randomized trial in 250 inner-city children with asthma enrolled in a program aimed to improve adherence. The study examined the longitudinal effects of a home-based asthma education program combined with medication adherence feedback. In the group that received asthma education with adherence feedback, short-term improvements in adherence were noted. However, this improvement decreased over time. In addition, no difference in adherence was found between the two groups receiving asthma education either with or without feedback. This study demonstrated that asthma education improved adherence in the short term but that adherence feedback did not improve outcomes over education alone [13].

Access and the Health Care Setting

In a study examining differences in prevalence, treatment, and outcomes of asthma among children (n=822,900) receiving equal access to care, African American and Hispanic children were more likely to be diagnosed with asthma and to have potentially avoidable asthma hospitalizations and asthma-related emergency department visits, and they were significantly less likely to visit a specialist compared with white children. Surprisingly, the study also showed that African American children were more likely to have filled a prescription for ICS than white children [14•].

Lui et al. [15•] evaluated the prevalence of uncontrolled asthma in pediatric patients visiting their primary care provider (PCP) for any reason. Forty-six percent of the 2429 children studied had uncontrolled asthma. Among patients seeing a PCP for a nonrespiratory complaint, 35% had uncontrolled asthma, and 54% of the children with a respiratory complaint had uncontrolled asthma. When stratified by race/ethnicity, the prevalence was higher for uncontrolled asthma in African American children, with 60% seeing a PCP for a respiratory complaint and 44% seeing a PCP for a nonrespiratory complaint. Hispanic children seeing a PCP for a respiratory complaint had an uncontrolled asthma prevalence of 51%, and the prevalence was 32% among those seeing a PCP for a nonrespiratory complaint. This study demonstrated a high prevalence of uncontrolled symptoms in African American and Hispanic children with a history of asthma in the primary care setting. There was also a high prevalence of uncontrolled asthma in those without a history of asthma [15•].

The setting in which pediatric patients with asthma receive their care has a significant impact on disparity. The Galbraith et al. [16] study examined asthma care quality for children seeing minority-serving providers (providers seeing>25% minorities) and found that children with persistent asthma were less likely to be prescribed inhaled steroids when receiving care from community health centers or hospital clinics compared with multispecialty group practice. In this setting, children were more likely to have never received inhaled steroids than children whose providers were not minority serving. The data from this study confirmed that observed associations of inhaled steroid use with patient race/ethnicity and minority-serving providers were largely mediated by practice setting [16].

Socioeconomic Status

According to Williams et al. [17], children living in poverty, irrespective of their ethnicity, and nonwhite children living in urban areas have a significantly higher risk of asthma-specific disease morbidity. Characteristics of SES at the individual, household, and community level affect a child's risk of asthma. Compared with high SES children, poor children are exposed to higher levels of family turmoil, violence, separation, instability, and chaotic household conditions. The authors cited a study of 851 children enrolled in the Inner-City Asthma Study that demonstrated an association between violence and increased caretaker-reported asthma symptoms. A cohort study in Boston linked greater lifetime exposure to community violence and increased risk of asthma, wheeze, and bronchodilator use [17].

Although several studies have documented an association between low SES and asthma, there are contradictions. One study examined the association between SES and asthma based on income trajectories. In this study, 2868 children enrolled in a pregnancy registry in Western Australia were followed up at 1, 2, 3, 6, 8, 10, and 14 years. The researchers assessed the likelihood of the children having asthma at 6 years and 14 years relative to their family income trajectory. Twenty-two percent of children from low-income families had asthma at 6 years. The risk of asthma was higher in children living in chronically low-income households, and the risk of asthma at 6 years of age was greater among male children exposed to chronically low income. Children in the increasing income trajectory group had the lowest asthma prevalence. In addition, single-parent status was positively, but not significantly, associated with asthma at 6 years. Pregnancy, early-life stress, and family stress were independently associated with asthma at 6 years [18].

The risk of asthma at age 14 years was threefold greater among female children exposed to chronically low income, and children who lived in low-income households since birth had a twofold increased risk of having asthma at age 14 years. The association of chronically low income was stronger at age 14 years than at age 6 years, but the strength of this association diminished after accounting for family stress. Single-parent status and increasing income were associated with a decreased risk of asthma at age 14 years, and the associations were gender specific. Children living in low-income households had higher rates of exposure to endotoxin and infections, which may protect them against asthma development. According to the authors, these exposures may disappear once household income improves, but at that point, they already would have had their effect in shaping and developing the infant immune system [18].

A study by Bacon et al. [19] demonstrated that low SES was associated with worse asthma control, greater emergency service use, and worse asthma efficacy. However, low SES was not related to worse asthma quality of life. This apparent contradiction might be explained by low perceptions and expectations for quality of life. The authors noted that patients with lower SES were more likely to exhibit poor health behaviors that may exacerbate asthma [19].

Vitamin D and Asthma

Poor nutrition often observed in low SES families also may play a role in pediatric asthma disparity, particularly with respect to the consumption of vitamin D. A recent study on children with asthma from Costa Rica showed a significant inverse association between vitamin D levels and use of anti-inflammatory medication, total IgE levels, and eosinophil counts [20]. Searing et al. [21] demonstrated that decreased vitamin D levels in children with asthma were associated with increased corticosteroid use. Forty-seven percent of the participants had 25-hydroxyvitmain D serum levels in the insufficient range (<30 ng/mL), and 17% were vitamin D deficient (<20 ng/mL). There was an association between lower vitamin D levels and increased atopy as characterized by positive aeroallergen skin prick test responses. FEV_1 percentage predicted, and FEV_1/FVC ratio showed a significant positive association with vitamin D sufficiency [21]. A study based on data from the National Health and Nutrition Examination Survey demonstrated that non-Hispanic African American adolescents had 20 times the risk of vitamin D deficiency compared with non-Hispanic whites, and the risk of deficiency in this group was double for females compared with males [22].

In a study comparing vitamin D status of healthy, low-income minority children in Atlanta, a significantly larger proportion of non-Hispanic African American children had vitamin D deficiency compared with Hispanic children. Dietary intake of vitamin D showed no significant relationship with serum vitamin D or serum calcium levels, but there was an inverse relationship between fat intake and serum levels of vitamin D and calcium. The overall prevalence of vitamin D deficiency was 22% in this group of healthy minority children from low-income families in Atlanta [23]. A study examining vitamin D deficiency in inner-city African American children with asthma in Washington, DC, also found that most of the urban youth were vitamin D deficient compared with the controls without asthma, thus confirming that African Americans are more vitamin D deficient than other groups [24].

Vitamin D levels also may play a role in the severity of asthma exacerbations. Recent analysis of the serum collected from children enrolled in the Childhood Asthma Management Program study showed that 35% of the participants were vitamin D deficient, with African Americans having the lowest mean levels of vitamin D. After adjusting for age, sex, body mass index, income, and treatment group, insufficient levels of vitamin D were associated with higher odds of any hospitalization or emergency department visit. According to the study, odds of an asthma exacerbation were highest in the group of children who were vitamin D insufficient and not taking ICS compared with the group that was vitamin D sufficient and receiving ICS. The authors posited that increased vitamin D levels might improve handling of infection and inflammatory responses that may result in less severe disease and sequelae of viral infections. These data suggest that although the number of exacerbations did not differ in the course of the 4-year study, the severity of exacerbation might be worse in children who are vitamin D insufficient. The benefits of vitamin D supplementation are now being studied by various groups, and although the supplementation levels for optimal immune function and its relationship to asthma are unknown, the authors believe that benefits are likely to be greatest in African Americans and those who are already receiving inhaled steroids [25].

Conclusions

The disparities in pediatric asthma clearly are significant. The current body of work suggests that these disparities are the result of gene–environment interactions, SES, culture and ethnicity, and associated health beliefs. The recent data regarding vitamin D also suggest a putative role for vitamin D metabolism in these disparities. Ultimately, additional prospective studies based on these findings and possible relevant interventions are sorely needed.

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