Chapter 9
Health Disparities in Asthma

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Key Points

- Children, women, racial and ethnic minorities, residents of inner cities, and economically disadvantaged populations have a significantly higher burden of asthma.
- Health disparities in asthma result from a complex interaction of multiple factors including: patient-related factors, factors related to the health care system, as well as social and environmental factors.
- Future research on asthma health disparities should involve a multidisciplinary and simultaneous examination of the complex interactions between the individual, socioeconomic, cultural, and health system factors involved.

Introduction

When compared to the general population or other populations, children, women, racial and ethnic minorities, residents of inner cities, and economically disadvantaged populations in the United States have a significantly higher burden of asthma [1–4]. Children in the United States have twice the self-reported asthma attack prevalence rates and two to three times the annual rate of emergency department (ED) visits for asthma than adults [2, 4]. Among adults, women have twice the annual rate of ED visits for asthma when compared to men [4]. In terms of disparities by geographic location, several studies from three decades ago in large US cities such

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as Boston, Chicago, Los Angeles, and New York City, revealed significantly asthma morbidity and mortality in inner-city neighborhoods compared to suburban areas [5–8]. Residents of inner-city neighborhoods are also more likely to be of low socioeconomic status (SES) and have poor access to care [8, 9]. Racial and ethnic minority populations also have a high burden of asthma [10]. For the purposes of this chapter, race will refer to white, Black or African American, Asian, Hawaiian or other Pacific Islander, and American Indian or Alaska native. Ethnicity will refer to Hispanic or Latino and not Hispanic or Latino. In the United States, data shows that compared to non-Hispanic whites, racial and ethnic minority populations have significantly higher morbidity andmortality from asthma [2, 4]. Economically disadvantaged populations, many of whom are from racial/ethnic minority groups, and predominantly reside in inner-city neighborhoods have a significantly higher burden of asthma [8]. According to the Expert Panel Report 3 (EPR3) guidelines on asthma published by National Heart, Lung, and Blood Institute (NHLBI) in 2007, ethnic and racial disparities in asthma burden are a persisting problem—with significant negative impact on African American and Puerto Rican populations—despite overall improvements in mortality from asthma [11].

Health disparities in asthma probably result from a complex interaction of multiple factors including: patient-related factors, factors related to the health care system, as well as social and environmental factors [12, 13]. The burden of asthma health disparities necessitates an increase in resources directed to studying the mechanisms that lead to and sustain asthma health disparities [14, 15]. The CDC *Health Disparities and Inequalities Report—United States*, *2011* includes a detailed report of prevailing asthma disparities in the US population [2, 16]. It also offers recommendations for addressing health disparities in asthma [16]. The ultimate goal is to develop evidence-based strategies for addressing issues of asthma health disparities.

In this chapter, we will review the epidemiology of asthma in the USA, with a special focus on the burden of asthma among children, women, racial/ethnic minorities, and economically disadvantaged populations, who are disproportionately negatively affected. We will then explore the factors associated with asthma health disparities in the USA. Next, we will discuss a conceptual model that has been proposed to explain the interaction of various factors associated with asthma health disparities. Currently proposed strategies for addressing asthma health disparities will be then reviewed. Finally, a summary of federal programs directed at addressing asthma health disparities will be presented.

Asthma Overview

Asthma is a common chronic inflammatory disorder of the airways, characterized by episodic and reversible airflow obstruction, airway hyperresponsiveness, and underlying inflammation [11]. These features interact to determine the clinical syndrome of asthma which includes one or more of the following clinical manifestations: recurrent wheezing, coughing—especially at night, shortness of breath, chest

tightness, and exercise limitation [11]. Intermittent episodes of increased asthma symptoms—asthma attacks—typically occur after exposure to specific asthma triggers such as viral respiratory infections, mold, pollen, dust mites, cockroach allergen, tobacco smoke, outdoor air pollution, strong odors and fumes, exercise and physical exertion, cold air, stress, etc.

The hallmark of asthma is a variable and reversible airflow obstruction—secondary to bronchoconstriction [11]. Reversibility can occur spontaneously or in response to treatment with bronchodilators [11]. A diagnosis of asthma is usually suggested by the characteristics and pattern of typical asthma symptoms, especially in association with known exposure or sensitization to specific asthma triggers. Evidence of significant reversibility of airflow obstruction with bronchodilators, or significant hyperresponsiveness to airway constrictor agents such as methacholine, or a positive response to appropriate asthma therapy confirms the diagnosis of asthma [11]. The management of asthma is multifaceted and aims to reduce the risk of asthma morbidity, functional impairment related to asthma, and mortality [11]. The main tenets of management include trigger reduction and avoidance, assessing level of asthma control, medication therapy, and monitoring level of disease activity [11]. In many asthma patients, current treatment strategies are effective in controlling symptoms. Unfortunately, no therapy has been shown to significantly alter the natural course of asthma. This is likely due to our limited understanding of the natural history of asthma.

Several studies, including cohort studies in the U.S. have examined the natural history of asthma from birth, through adolescence to young adulthood [17, 18]. Distinct early childhood wheezing phenotypes as well as risk factors for persistent wheezing and subsequent asthma diagnosis have been identified [19]. The inherent heterogeneity of the asthma phenotype, variable response to asthma therapy, and the different temporal trajectories that asthma patients follow from early childhood through adulthood complicate our current understanding of the natural history of asthma. Few cohorts have studied the natural history of adult asthma [20–22]. A variety of studies, using both biased (hypothesis-based) approaches or unbiased (statistical-based) approaches have identified distinct phenotypes of asthma in adults including early onset allergic asthma, late-onset eosinophilic asthma, exercise-induced asthma, obesity-related asthma, and neutrophilic asthma [23–27]. It should be noted that the number and features of subphenotypes identified in these studies are limited by the study population and the choice of variables included in the analysis, regardless of the approach used.

Asthma Disparities in the United States

Disparities in Asthma Prevalence

Differences exist in asthma prevalence by age group, gender, race, SES, and geographic region in the United States [2]. According to surveillance data for the period 2008–2010, the average annual current asthma prevalence was higher in children

than adults (9.5 % versus 7.7 %), higher in females than in males (9.2 % versus 7.0 %), higher in blacks than in whites (11.2 % versus 7.7 %), higher among Hispanics with roots in Puerto Rico versus Hispanics with roots in Mexico (16.1 % versus 5.4 %), higher among persons with family income below 100 % of federal poverty threshold versus those with family income at or above the federal poverty threshold (11.2 % versus 8.5 %) [10]. In terms of geographic region, the current asthma prevalence rate was higher in the Northeast and Midwest than in the South (8.8 % versus 7.6 %) [10]. In the West, the reported asthma prevalence rate was 8.0 % [10]. Interestingly, there was no difference between metropolitan and nonmetropolitan areas in terms of current asthma prevalence [10]. Previous reports have reported similar racial differences in asthma prevalence [28–30]. In a 1987 report of U.S. asthma surveillance data for the period from 1965 to 1984, significant differences in asthma prevalence rates, emergency department visit rates, and hospitalization rates by race/ethnicity were reported [30]. Other reports from the Centers for Disease Control and Prevention (CDC) have generally confirmed these significant racial and ethnic disparities in asthma morbidity and mortality [2, 15, 16]. In 2011, the CDC analyzed data from the National Health Interview Survey (NHIS) for the period 2006–2008 and reported both lifetime asthma prevalence and current prevalence of asthma by various demographic subgroups [2, 16]. According to the 2011 CDC Health Disparities and Inequalities Report (CHDIR), the estimated current prevalence of asthma of the U.S. population was 7.8 % with significant variation by racial or ethnic group. Current asthma prevalence was 15.9 % among Puerto Ricans, 14.4 % among multiracial/other-race persons, 10.5 % among blacks, 10.8 % among American Indians/Alaska Natives, 7.9 % among whites, and 5.4 % among Mexicans [2, 12]. In that report, current asthma prevalence also varied by age, gender, and SES. Current asthma prevalence was higher among children (9.3 %) than among adults (7.3 %). It was also higher among females (8.6 %) than among males (6.9 %), and among those considered poor (11.2 %) than those considered nonpoor (7 %). Among children (0–17 years of age) the racial/ethnic disparities in current asthma prevalence were even greater. The current asthma prevalence was 18.4 % among Hispanic children with roots in Puerto Rico, 14.6 % among non-Hispanic blacks, 13.6 % among multiracial children, and 8.2 % among non-Hispanic whites [2, 12]. Among adults, there was no difference in current asthma prevalence between non-Hispanic blacks (7.8 %) and non-Hispanic whites (7.7 %) [2, 12]. However, the current asthma prevalence was disproportionately higher among multiracial persons (15.1 %) and Hispanics with roots in Puerto Rico (12.8 %). An important finding is that the current asthma prevalence for Hispanics of Puerto Rican ancestry (14.2 %) is much higher than Hispanics of Mexican ancestry (4.9 %) [2, 12].

Disparities in Asthma Morbidity

The 2013 CHDIR report is based on data from the 2001–2010 NHIS survey and provides information about asthma attacks among persons with current asthma [4, 12, 14, 15]. The definition of asthma attacks was based on an affirmative response

to the following survey question—"During the past 12 months, have you had an episode of asthma or an asthma attack?" Some notable differences between the periods 2001–2004 and 2006–2010 exist in terms of proportion of reported attacks in the past year. In general, the period 2001–2004 had a slightly higher percentage of persons with current asthma who reported an asthma attack in the past year compared to the period 2006–2010. Overall, during the period from 2006 to 2010, asthma attacks were reported more frequently for females (53.5 %) than for males (48.8 %), and more frequently for children (56.1 %) than for adults (49.6 %) [4, 12]. In terms of differences by geographic region, even though the current prevalence of asthma was higher in the Northeast and Midwest than in the South and West, more asthma attacks were reported in the South (53.1 %) and West (54.5 %) compared to the Northeast (47.8 %) and the Midwest (49.4 %) [4, 10]. The survey assessed frequency of asthma attacks by level of education and did not find any significant differences between those with less than a high school education (51.2 %) and those with college or graduate education (52.1 %) [4, 31]. In terms of race or ethnicity, asthma attacks were reported more frequently among patients who self-identified as American Indian/Alaska Native (61.6 %) than among non-Hispanic whites (51.1 %), blacks (49.1 %), Hispanics with roots in Mexico (52.6 %), and Hispanics with roots in Puerto Rico (55.6 %) [4, 12]. It should be noted that only 92 (0.6 %) of the 14,230 patients sampled were American Indian/Alaska native [4, 12].

Significant differences in rate of ED visits for asthma by age, gender, and race or ethnicity were reported from the U.S. National Hospital Ambulatory Medical Care Survey (NHAMCS) for the period 2005–2007 [1, 4, 12]. Overall, children, especially those less than 5 years old, are more susceptible to asthma attacks requiring ED visits. Among children less than 5 years old, the annual rates of ED visits for asthma were higher when compared to children 5–17 years old (133/10,000 versus 73/10,000). Among adults, the annual rates of ED visits for asthma were lower than among children (47/10,000 versus 133/10,000 and 73/10,000 for children less than 5 years old and those 5–17 years old, respectively) [4]. Gender differences in annual rates of ED visits differed by age group [4]. Among children less than 5 years old, the annual rate of ED visits was higher for males than females (170.5/10,000 versus 94.1/10,000). Among adults, the annual rate of ED visits was higher for female than males (61.5/10,000 versus 32.7/10,000). For those 5–17 years old, there was no difference in annual rates of ED visits by gender (74.5/10,000 and 71.9/10,000 for males and females, respectively) [4]. In terms of race and ethnicity, the annual rates of emergency department visits for blacks (167/10,000) were significantly higher compared to whites (42.5/10,000) [4, 12]. Among Hispanics, the rates were 64.8/10,000. The data on Hispanics does not differentiate between the different subgroups of Hispanics.

According to the 2004 National Hospital Discharge Survey, the estimated rate of hospital discharges with asthma listed as the first diagnosis was significantly higher for blacks (33.5/10,000) than for whites (10/10,000) or other races (19/10,000) [12, 32]. The U.S. NHAMCS does not include information on metropolitan versus nonmetropolitan residences or SES. However, previous studies in the 1990s showed that hospitalization for asthma was more common among patients from poor inner-city neighborhoods compared to those from more affluent suburban neighborhoods [5–7].

Disparities in Asthma Mortality

Several studies in the 1980s and 1990s showed in several US metropolitan areas, mortality from asthma was significantly higher in inner-city neighborhoods compared to suburban areas [5, 7–9, 33, 34]. Inner-city populations tend to be of low SES, be racial or ethnic minorities, have poor access to care, be more exposed to environmental pollutants, and live in crowded conditions leading to increased exposure to allergens and infections [9, 33]. This higher mortality is likely due to a complex interaction of multiple factors that are characteristic of life in large urban poor neighborhoods. In terms of racial or ethnic differences in asthma mortality, data from the National Vital Statistics System (NVSS) for the period 1990–2007 showed a significantly higher mortality due to asthma for blacks compared to whites, especially among children ages 0–17 years old [4, 12, 35]. Among children ages 0–17 years old, the annual rate of deaths with asthma as the underlying cause of death among blacks was 0.8/100,000 compared to 0.1/100,000 among whites and 0.2/100,000 among Hispanics. Among adults older than 18 years, there is also a significant difference between blacks and other races in terms of the annual rate of deaths with asthma as the underlying diagnosis. However, it should be noted that there has been a trend toward a decrease in asthma-related mortality among blacks from 4.8 deaths per 100,000 in 1999–2001 to 3.4/100,000 in 2005–2007 [12]. Comparatively, among whites older than 18 years old, the annual rate of deaths due to asthma was 1.2/100,000 [12].

In summary, U.S. surveillance data as reported by the CDC reveals significant disparities in the prevalence, morbidity, and mortality related to asthma. Children, women, economically disadvantaged persons, and certain racial or ethnic groups (Africa-Americans, Puerto Ricans, multiracial persons, and American Indian/Alaska Natives) are disproportionately negatively impacted by asthma in terms of prevalence, urgent care and emergency department visits, hospitalizations, and fatalities due to asthma when compared to non-Hispanic whites. The prevalence of asthma among African Americans is about 40 % higher than in non-Hispanic white Americans [12]. The mortality from asthma among African Americans is twice that of non-Hispanic whites [12]. Puerto Ricans have a higher asthma prevalence and mortality than African Americans [12]. Mexican Americans have lower asthma prevalence, morbidity, and mortality than non-Hispanic whites, African Americans, and Puerto Ricans [12]. The possible explanations for these racial/ethnic disparities in asthma are multifactorial, complex, and poorly understood. This is an active area of research. In the next section, we will explore the associations between putative factors and racial/ethnic disparities in asthma.

Factors Associated with Asthma Health Disparities

Many factors contribute to the observed health disparities in asthma [12, 13]. The relative impact of each factor is difficult to quantify. It is more likely that a complex interaction of several factors contributes to observed disparities in asthma

prevalence, morbidity, and mortality [13]. Studying the factors associated with asthma disparities involves a multidisciplinary approach involving various stakeholders including: patients or community advocates from racial or ethnic minority populations, health providers including asthma specialists, basic and clinical researchers, social cognitive researchers, health care administrators, and other government administrators. For ease of discussion, the factors associated with health disparities in asthma are classified into the following three categories: patient-related factors, social/environmental factors, and factors-related to health care providers or the health care system [13]. For each of these categories, we discuss available evidence of an association with differences in prevalence, severity, and mortality of asthma. We also discuss how these factors might interact with each other to increase the disparities.

Patient-Related Factors

There is evidence that genetic factors might play a role in racial/ethnic differences in asthma prevalence and severity. The best example is seen among Hispanics in the United States with a significant difference in prevalence, severity, and mortality between Hispanics of Puerto Rican origin and Hispanics of Mexican heritage [12]. This observation is commonly described as the *Hispanic paradox*. Burchard et al. showed that bronchodilator responsiveness was 7.3 % lower in Puerto Ricans compared to Hispanics with roots in Mexican [36]. A subsequent genetic study showed that bronchodilator responsiveness was strongly associated with Arg16Gly genotypes in Puerto Ricans but not in Mexicans [37]. Racial differences in certain physiologic variables between American children of European descent and African American children were reported by Joseph et al. [38]. Compared to a matched cohort of American children of European descent, middle-class African American children with asthma had decreased forced vital capacity (FCV) and forced expiratory volume in 1 s (FEV1) [38]. They also had increased airway hyperresponsiveness and increased total serum immunoglobulins E (IgE) levels [38]. Compared to non-Hispanic whites, Puerto Rican and African American children were noted to be significantly more likely to be allergic to several outdoor allergens [39]. Genome-wide association studies (GWASs) have confirmed the important contribution of genetic component to asthma but do not fully explain the observed racial or ethnic disparities [40, 41]. Even though racial or ethnic variability in the distribution of some genetic polymorphisms might determine susceptibility to asthma, this is not sufficient to explain observed ethnic differences in asthma observed in the United States [42]. The asthma phenotype is a complex trait that is determined by multiple genes contributing small effects, by gene–gene interactions and by the complex interactions between the genes and numerous environmental factors [42, 43]. The natural history and the pathobiology of asthma are poorly understood. An important concept in the pathobiology of asthma is the hygiene hypothesis which posits that a reduction in endotoxin exposure or microbial load in early life might alter the balance of the immune system in favor of the more active T-helper type 2 responses

that are involved in asthma and allergy [44, 45]. However, the hygiene hypothesis does not explain the high prevalence and morbidity of asthma seen in inner-city African Americans. After all, inner-city African American children do not necessarily experience fewer infections than children from other demographic groups in the United States.

It has been argued that the widening disparities in the prevalence and severity of asthma over the past 3 decades are too rapid to be explained by changes in genetic factors alone [13]. Therefore, other modifiable patient-related behavioral factors likely contribute to these health care disparities. Some families have misconceptions about the susceptibility to asthma [13]. Poor adherence to provider-recommended asthma therapy is another possible factor contributing to high asthma morbidity in minority populations. Common beliefs about the efficacy and safety of medications vary by ethnicity [13]. Minority populations are generally less trusting of standard therapy and are more inclined to try other alternative therapies [46, 47]. A study of 40 parents of children with asthma revealed numerous concerns and barriers to asthma medication use among African American parents [46]. The long-term complications of daily asthma medications use were the most cited concern [46]. There is also evidence of frequent use of home remedies to manage asthma among African Americans and Latinos [47–50]. These attitudes can lead to a delay of appropriate therapy and consequently, more severe disease. Asthma care requires a very active participation from the patient or parent to monitor for changes in control and institute timely interventions. A poor understanding of the disease and lack of awareness about possible complications can contribute to significant disparities in morbidity and mortality of asthma irrespective of prevalence. Racial and ethnic minority populations have a lower health literacy rate than non-Latino whites and might not adequately comply with treatment recommendations of asthma care [51, 52]. An important risk factor for asthma is obesity [53]. The prevalence and severity of obesity among African Americans and Hispanics, especially in poor urban environments is much higher than among non-Hispanic whites and might also contribute to the disparity in asthma burden [54].

Social and Environmental Factors

A concern in interpreting racial and ethnic differences in asthma prevalence, severity, and mortality is the possibility of confounding by SES and other environmental factors [55]. In general, persons with low SES in the United States have poorer health [55–57]. Racial and ethnic minorities are more likely to have a low SES. Compared to non-Hispanic whites, African Americans have higher mortality rates for most illnesses including asthma [55]. They also live in poorer and segregated neighborhoods, mostly in urban areas [55]. These neighborhoods are characterized by higher levels of environmental pollution and stress due to violence. Environmental pollution and stress are well-established risk factors for asthma morbidity and mortality [58]. Indoor allergens such as the cockroach allergen are associated with increased asthma morbidity [59, 60]. Concentrations of the cockroach

allergen are higher in urban homes compared to rural homes. High levels of cockroach allergens are also associated with low SES and African American race [61]. The National Cooperative Inner-City Asthma Study (NCICAS) showed that 85 % of homes had detectable cockroach allergen and 37 % of patients had a positive skin test to cockroach allergen [62, 63]. A combination of high allergen levels in the patient's bedroom and cockroach sensitivity was associated with increased days with wheezing, increased emergency department visits, and increased hospitalizations [62]. Exposure to diesel particles in urban areas is also associated with increased asthma morbidity [64]. Persons with low SES are more likely to reside close to major highways and thus be more exposed to diesel particles [65, 66]. They are also more likely to reside in homes with poor ventilations compared to more affluent suburban residents [59, 67]. Other socioeconomic factors characteristic of life in poor urban neighborhoods and associated with increased asthma morbidity include: poor diet, physical inactivity, obesity, environmental smoke exposure, and depression. Among 4-year-old children, low SES was shown to be a risk factor for asthma [68]. Another study showed that independent of ethnicity and family income, children in low socioeconomic communities had 70 % greater risk of asthma [69]. Saha et al. showed that in a low SES neighborhood, age, race, gender, and body mass index (BMI) were significant predictors of childhood asthma [70].

Patients with low SES also have poor social and/or family function which might impact compliance with treatment recommendations of asthma care. There is an increasing body of evidence linking chronic stress in high-risk neighborhoods and increased asthma exacerbations [58, 71–73]. Chronic stress is associated with increased oxidative stress and this can also lead to an increase in incidence of asthma [71, 72]. Chen et al. showed that children of low SES overexpressed genes that regulated chemokine activity, stress response, and wound healing [74]. On the other hand, children of higher SES overexpressed genes that maybe be involved in containing damage caused by inflammation [74]. It has been suggested that chronic stress and threat perception in low SES neighborhoods might lead to a higher production of markers of eosinophil production and activation. Respiratory syncytial virus (RSV)-induced bronchiolitis in infancy is a risk factor for subsequent development of asthma [75–78]. Studies show that American Indian and Alaska Native infants are significantly more likely to be hospitalized for RSV infections [79, 80]. This might explain the significant asthma disparity in these populations. Children from low SES in inner cities are also more likely to have recurrent hospitalizations for RSV but the current data does not show significant differences between non-Latino whites and other racial or ethnic minorities in inner cities [33].

Factors Related to Health Care System and Health Care Providers

The management of asthma is multifaceted and includes preventive measures such as avoidance and control of relevant triggers, regular use of controller medications, and timely referral to asthma specialists [11]. There is evidence that many health

care providers, especially those who treat racial and ethnic minority populations in inner cities, do not adhere to well-established asthma management guidelines [13]. In one study, pediatricians in practices with more than 25 % of African American children in their practice reported less prescription of daily controller medications (35 %) when compared to pediatricians in all practices (51 %) [13, 81]. It is not clear if limited access to care contributes to observed asthma disparities. Blixen CE et al. showed that African Americans were less likely to have primary care or subspecialty visits for asthma but were more likely to have ED visits for asthma [82]. There are also other important racial and ethnic disparities in medication and healthcare usage for asthma [3]. Analysis of 1485 patients surveyed as part of the National Asthma Survey Database showed that African American and Hispanic children were less likely to have used inhaled corticosteroids (ICS) than white children. They were more likely to receive daily short-acting bronchodilators (SABAs) than white children. Black children had twice as many ED visits and hospitalizations than white children and emergency department visits were positively correlated with SABA use and negatively correlated with ICS use when stratified for race and ethnicity [3]. Compared to non-Hispanic whites, racial and ethnic minority patients in inner cities are more likely to rely on government-sponsored health care plans, such as Medicaid. These health care plans are more tightly regulated for cost control and might limit access to asthma specialists. Overall, there is some suggestion, based on limited available evidence, that minority populations might receive lower quality asthma care, thus contributing to the observed disparities in asthma [12, 13]. Asthma controller medications are expensive and some states have attempted to reduce cost by introducing copayments. Many patients of low SES, especially those of racial and ethnic minority populations have difficulty affording these copayments. The consequence is an increase in frequency of asthma exacerbations and emergency department use for asthma.

It has been suggested that ineffective communication between provider and asthma patients because of racial or ethnic differences might result in misclassification of asthma symptom severity [13]. Such misclassification of asthma severity may lead to undertreatment of asthma and ultimately contribute to the observed racial or ethnic disparities in asthma care. A study of about 3500 asthma patients (13 % black) showed that black patients were significantly more likely than white patients to have their asthma severity underestimated [83]. The study also noted that among the black patients, underestimation of asthma severity was associated with less use of daily ICS, less physician instruction on management of asthma flare-ups, and lower ratings of asthma care and communication [83]. Another suggestion is that unconscious biases against low income and or racial or ethnic minority patients by the provider that might affect the quality of care provided to the patient [13]. A perception that low income and or racial or ethnic minority patients with asthma are noncompliant might affect the quality of care provided. The provider might not take the time to adequately explore the reasons for uncontrolled disease, simply attributing this to noncompliance.

In summary, there is clear evidence of significant disparities in asthma prevalence, morbidity, and mortality in the United States. Asthma disproportionately

negatively affects low-income Americans and especially racial/ethnic minorities such as Puerto Ricans and African Americans. These disparities might very well be genetically based. However, they are also mitigated by socioeconomic, environmental, and cultural factors that limit simplistic explanations. Simply highlighting phenotypic racial differences is a poor surrogate for understanding the interaction between biologic, environmental, and cultural factors that lead to and sustain these disparities in asthma.

Strategies for Addressing Health Disparities in Asthma

The CDC *Health Disparities and Inequalities Report—United States*, *2011* reports recommended certain actions to reduce health disparities in general [2]. These include an increase in community awareness of disparities, setting priorities among the disparities to be addressed, using evidence-based and proven strategies for eliminating health disparities, and a need-based allocation of resources to reduce disparities. Canino et al. have proposed a conceptual model which incorporates a range of risk factors at multiple levels as a first step to understanding and ultimately addressing asthma disparities in the United States [13]. Future research on asthma health disparities should involve a multidisciplinary and simultaneous examination of the complex interactions between individual, socioeconomic, cultural, and health system factors involved. More importantly, adequate representation of members of high-risk populations and minority investigators should be involved in the research. Community-based participatory approaches utilizing community resources should be used. Community-based programs are effective in modifying outcomes because they emphasize engagement, education, and empowerment of the affected populations. An increased focus on validating effective models of education and care that is driven by community stakeholders is therefore needed. In addition to the community approaches, focused research to investigate unique markers that predict disease severity and therapeutic response in racial and ethnic minority populations is needed.

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