State of the Art

Asthma in Hispanics

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Hispanic individuals trace their ancestry to countries that were previously under Spanish rule, including Mexico, large parts of Central and South America, and some Caribbean islands. Most—but not all—Hispanics have variable proportions of European, Amerindian, and African ancestry. Hispanics are diverse with regard to many factors, including racial ancestry, country of origin, area of residence, socioeconomic status, education, and access to health care. Recent findings suggest that there is marked variation in the prevalence, morbidity, and mortality of asthma in Hispanics in the United States and in Hispanic America. The reasons for differences in asthma and asthma morbidity among and within Hispanic subgroups are poorly understood but are likely due to the interaction between yet-unidentified genetic variants and other factors, including environmental tobacco smoke exposure, obesity, allergen exposure, and availability of health care. Barriers to optimal management of asthma in Hispanics in the United States and in Hispanic America include inadequate access to health care, suboptimal use of antiinflammatory medications, and lack of reference values for spirometric measures of lung function in many subgroups (e.g., Puerto Ricans). Future studies of asthma in Hispanics should include large samples of subgroups that are well characterized with regard to self-reported ethnicity, country of origin, place of birth, area of residence, and indicators of socioeconomic status. Because Hispanics are disproportionately represented among the poor in the United States, implementation of adequate access to health care and social reforms (e.g., improving housing conditions) would likely have a major impact on reducing asthma morbidity in this population.

Keywords: asthma; genetics; Hispanics; risk factors

CONTENTS

- The Hispanic Population
 - Hispanic America
 - United States
- Asthma Prevalence in Hispanics
 - Hispanic America
 - United States
- Morbidity and Mortality of Asthma in Hispanics
 - Hispanic America
 - United States
- Potential Risk Factors for Asthma in Hispanics
 - The Genetics of Asthma in Hispanics

- Genetic Studies
- SES and Asthma in Hispanics
- Air Pollution
- Passive Exposure to Smoking
- Obesity and Asthma in Hispanics
- Allergen Exposure, Allergen Sensitization, and Asthma in Hispanics
- Parasitic Infection and Asthma in Hispanics
- Migration and Acculturation
- Diagnosis of Asthma in Hispanics
- Asthma Management in Hispanics
 - Hispanic America
 - United States
- Future Directions

Although asthma is a major public health problem in the United States (1) and worldwide (2–4), there is marked variation in the prevalence, morbidity, and mortality of asthma among and within nations (3–5). The Hispanic population is diverse with regard to multiple factors such as race, country of origin, area of residence, education, access to health care, and socioeconomic status (SES). Over the last 10 years, there has been increasing recognition of profound differences in the prevalence, morbidity, and mortality of asthma among different Hispanic subgroups in the United States and Hispanic America (5–10).

The purpose of this article is to provide clinicians, public health practitioners, and researchers with a comprehensive review of asthma in Hispanics. After a brief overview of Hispanic populations, we will review published studies on asthma in Hispanics, including evidence regarding prevalence, morbidity, and mortality; genetics; sociodemographic and environmental factors that may influence asthma and/or asthma morbidity, including SES, air pollution, environmental tobacco smoke (ETS) exposure, obesity, exposure and sensitization to allergens, parasitic infections, and migration and acculturation; diagnosis; and management. For each section, we will separately discuss findings for Hispanic America and the United States whenever appropriate. Finally, we will propose future directions for research in this field.

THE HISPANIC POPULATION

The term “Hispanic,” as applied in U.S. census data (11, 12), refers to peoples with roots in Spain or in areas that were previously under Spanish control, including Mexico, large parts of Central and South America, and some Caribbean islands.

Hispanic America

Because of the vastness of the old Spanish Empire, Hispanics live in geographically diverse areas ranging from deserts to tropical areas to sea coasts to mountains. Table 1 shows selected demographic characteristics of some Hispanic-American countries. Although none of these nations is among the wealthiest

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TABLE 1. SELECTED DEMOGRAPHIC AND HEALTH CARE DATA FROM SELECTED HISPANIC COUNTRIES

Country	Per Capita GDP*	HDI†	IMR‡	Life Expectancy§	Health Spending	Asthma Deaths¶
Argentina	\$12,400	0.853	15.18	75.91	\$238	
Chile	\$10,700	0.839	8.8	76.58	\$246	12.82
Colombia	\$6,600	0.773	20.97	71.72	\$151	13.44
Costa Rica	\$9,600	0.834	9.95	76.84	\$383	10.10
Guatemala	\$4,200	0.649	35.93	65.14	\$93	
Mexico	\$9,600	0.802	20.91	75.19	\$379	18.74
Nicaragua	\$2,300	0.667	29.11	70.33	\$60	18.47
Peru	\$5,600	0.752	31.94	69.53	\$93	7.55
Commonwealth of Puerto Rico (possession of the United States)	\$17,700		8.24	77.62		37.19

Definition of abbreviations: GDP = gross domestic product; HDI = Human Development Index; IMR = infant mortality rate.

* The GDP is total market value of all final goods and services produced in a country in a given year, equal to total consumer, investment, and government spending, plus the value of exports, minus the value of imports in U.S. dollars. Source: CIA World Factbook, June 2005.

† The HDI is calculated using various indicators for quality of life, such as health indicators and access to health care services, life expectancy at birth, nutrition levels, education and literacy levels, access to basic needs such as water and sanitation, and so on. It also takes into account GDP per capita in terms of Purchasing Power Parity and percentage of the population living below the poverty line. Source: Human Development Reports: United Nations, 2002.

‡ The IMR is the number of children dying under a year of age divided by 1,000 live births. Source: CIA World Factbook, June 2005.

§ Life expectancy is the average number of years to be lived by a group of people born in the same year, if mortality at each age remains constant in the future. Source: CIA World Factbook, June 2005.

|| Health spending is the health care spending per capita in 1998 U.S. dollars. Source: World Bank, 2002. World Development Indicators 2002.

¶ Asthma deaths are expressed per 1 million people. Source: World Health Organization, 2002.

in the world, there is a wide range of gross domestic product (GDP) per capita. The estimated GDP per capita of Argentina and Nicaragua in 2004 ranked 71st and 168th, respectively, among 232 world nations (13). Recent estimates of infant mortality rate (a gross indicator of health care status at a national level) ranged from 6.33 deaths per 1,000 live births in Cuba to 53.11 deaths per 1,000 live births in Bolivia (ranking 40th and 165th, respectively, among 226 world nations in 2005) (13).

United States

According to the 2000 census, there were 35.2 million Hispanics in the United States, comprising approximately 12.5% of the population (12). Between 1990 and 2000, the Hispanic population in the United States increased by 60.7% (12). Hispanics are the fastest growing minority within the United States, and by 2050, their numbers are expected to triple, thus becoming 24.4% of the population (11, 14).

In the 2000 U.S. census, 47.9% of Hispanics characterized their race as white, 42.2% as other, 2% as black or African American, 1.2% as American Indian or Alaskan Native, and less than 1% as Asian, Native Hawaiian, or other Pacific Islander (15). Approximately 59.3% of Hispanics in the United States traced their roots to Mexico; 22.3% traced their ancestry to Puerto Rico, Central America, South America, or Cuba; and 18.3% came from other countries (e.g., the Dominican Republic) or characterized themselves as "other Hispanic" (Figure 1) (12).

Although Hispanics are less likely to graduate from high school than non-Hispanic whites, there is significant variation in educational attainment (16). In the U.S. mainland, the estimated proportions of adult Cubans, Puerto Ricans, and Mexicans who graduated from high school were 73, 64.3, and 51%, respectively. In 2000, Hispanics were more likely to live below the poverty level and to live in households with at least five people than non-Hispanic whites. In the U.S. mainland, the proportions of non-Hispanic whites, Cubans, Mexicans, and Puerto Ricans liv-

ing below the poverty level were 7.7, 17.3, 24.1, and 25.8%, respectively (16).

ASTHMA PREVALENCE IN HISPANICS

Hispanic America

Interpretation of many studies of the prevalence of asthma in Hispanic-American countries is limited by differences in methodology, including age of the study populations and definitions of asthma (17). As part of phase I of the International Study of Asthma and Allergies in Childhood (ISAAC) (10), data from standardized questionnaires on the prevalence of asthma and asthma symptoms were collected in children ages 6 to 7 years (by parental report) and/or in children ages 13 to 14 years (by self-report) in eight Hispanic-American countries (Tables 2 and 3) (4, 10, 18). Among 29,003 children ages 6 to 7 years, estimates of the prevalence of current wheezing and recurrent wheezing (≥ 4 attacks in the previous year) were lowest in Cuernavaca (Mexico) and highest in Costa Rica. In these children, the estimated prevalence of lifetime asthma was lowest in Buenos Aires (Argentina) and highest in Costa Rica. Among 37,095 adolescents, estimates of the prevalence of lifetime asthma and current

Figure 1. Country or region of origin of Hispanics in the 2000 U.S. Census.

TABLE 2. PREVALENCE OF SELECTED ASTHMA SYMPTOMS AMONG 6- TO 7-YEAR-OLD CHILDREN IN PHASE I OF THE INTERNATIONAL STUDY OF ASTHMA AND ALLERGIES IN CHILDHOOD IN HISPANIC AMERICA

Center	Current Wheeze	≥ 4 Attacks in Last Year	Ever Had Asthma	n
Argentina	16.4	3.8	5.3	6,012
Buenos Aires	15.4	3.2	4.1	3,005
Rosario	17.3	4.4	6.5	3,007
Chile	17.9	2.9	12.1	10,838
Central Santiago	16.5	1.6	9.7	1,458
Punta Arenas	17.1	2.1	10.4	3,060
South Santiago	16.9	2.6	10.5	3,182
Valdivia	20.5	4.5	16.5	3,138
Costa Rica	32.1	7.3	26.9	2,942
Mexico				
Cuernavaca	8.6	1.3	5.1	3,097
Panama				
David	23.5	4.1	19.3	3,043
Uruguay				
Montevideo	18.0	4.6	12.0	3,071

Data from Reference 10.

wheezing were lowest in Cuernavaca (Mexico) and highest in Lima (Peru). In this age group, the prevalence of recurrent wheezing was lowest in Puntarenas (Chile) and highest in Montevideo (Uruguay). In addition to variation in asthma prevalence among nations, there was also variability within countries. Among Chilean adolescents, estimates of the prevalence of lifetime asthma and current wheezing were lowest in Punta Arenas (a coastal city) and highest in central Santiago (an area of Chile's capital).

Phase I of ISAAC in Hispanic America had several limitations. First, many Hispanic-American countries did not participate in the study. Second, with the exception of Costa Rica, information on asthma prevalence was only collected in one to three cities. Third, there might have been inadequate comprehension of the questions on asthma and/or asthma symptoms by some participants, as adolescents often gave different responses

TABLE 3. PREVALENCE OF SELECTED ASTHMA SYMPTOMS AMONG 13- TO 14-YEAR-OLD CHILDREN IN PHASE I OF THE INTERNATIONAL STUDY OF ASTHMA AND ALLERGIES IN CHILDHOOD IN HISPANIC AMERICA

Center	Current Wheeze	≥ 4 Attacks in Last Year	Ever Had Asthma	n
Argentina	10.9	3.1	7.3	6,004
Buenos Aires	9.9	2.8	6.6	2,996
Rosario	11.8	3.4	7.9	3,008
Chile	10.2	1.5	10.7	12,708
Central Santiago	11.7	1.7	12.4	2,944
Punta Arenas	6.8	1.1	7.3	3,482
South Santiago	11.1	1.2	11.5	3,051
Valdivia	11.5	2.1	11.9	3,231
Costa Rica	23.7	5.3	18.5	3,200
Mexico				
Cuernavaca	6.6	1.5	5.5	3,102
Panama				
David	17.6	3.4	16.9	2,885
Paraguay				
Asunción	19.4	3.4	12.2	2,966
Peru				
Lima	26.0	4.8	28.0	3,158
Uruguay				
Montevideo	19.0	5.4	15.3	3,072

Data from Reference 10.

to a question on wheezing depending on the type of questionnaire administered (video vs. written) (19).

The need for validation of questions on asthma and asthma symptoms in Hispanic-American countries is underscored by recent findings of studies of children in cities (20, 21) and a state (22) of Mexico that used the ISAAC questionnaire. Two of these studies found a higher prevalence of asthma (22) or current wheezing (21) than that reported for Cuernavaca in phase I of ISAAC, and one study found marked discrepancies in reports of ever-wheeze (24.1%), current wheezing (49.8%), and ever-asthma (9.5%) (21). Although these findings may be due to regional differences in asthma prevalence, they may be explained by differences in the administration (22) or comprehension (21) of relevant questions.

There are scarce recent data on asthma prevalence in adults in Hispanic America. In a study of 6,507 subjects in six cities in Colombia, asthma was found in 13.8% of children and 7.6% of adults (23). However, these results are hard to compare with those of phase I of ISAAC (4, 10, 18) because of the asthma definition used (presence of either lifetime physician-diagnosed asthma or current wheezing). Among 1,279 adolescents and young adults (ages 17 to 33 years) attending universities in Costa Rica, estimates of the prevalence of active physician-diagnosed asthma and current wheezing were 8.2 and 10.6%, respectively (24). In addition to a relatively small sample size, this study was limited by nonrandom selection of the study population.

Little is known about asthma in rural areas of Hispanic America. Among 4,433 children in a tropical rural area of Ecuador (25), estimates of the prevalence of lifetime asthma and current wheezing were 10.3 and 2.1%, respectively. Similar findings were reported in 1,058 Mayan children in rural Guatemala (26). Thus, the prevalence of asthma and/or asthma symptoms among children in rural Ecuador and rural Guatemala was as low as that reported in rural areas of Africa (27).

Limited data are available on temporal trends in asthma prevalence in Hispanic-American countries (28–30). Soto-Quiros and colleagues compared the prevalence of asthma and wheeze in Costa Rican children at three time points (1989, 1995, and 1998) (29). From 1989 to 1998, there was no significant difference in lifetime wheeze (46.8% in 1989 and 45.1% in 1998), but physician-diagnosed asthma increased significantly (23 vs. 27.1%, $p < 0.05$). These findings, and those of a study in Villahermosa (Mexico), could be explained by increased awareness of asthma by local physicians (28). In another study, Vargas and colleagues examined health care use among subjects ensured by the Mexican Institute of Social Security (IMSS) from 1991 to 2001 (30). Although the total ensured population registered with a family physician increased by approximately 7.9 million subjects from 1991 to 2001, there were declines in annual rates of indicators of health care use (for all conditions and for asthma) and in the ratio of health care services for asthma relative to total health care services after 1997. It is unclear whether this finding represents reduced access to health care, improved asthma management, a reduction in the incidence of asthma, or a combination of these factors. Completion of phase III of ISAAC (10) should help explain temporal trends in asthma prevalence in Hispanic America.

In summary, the prevalence of childhood asthma is different among and within countries in Hispanic America. Limited data suggest that asthma prevalence is lower in rural than in urban areas of Hispanic America and that validation studies of common questions on asthma and/or asthma symptoms are needed in Hispanic-American countries.

United States

Results from several studies suggest that the prevalence of asthma is high in Puerto Ricans in the U.S. mainland (Table 4). In a study

TABLE 4. RESULTS OF SELECTED STUDIES OF THE PREVALENCE OF ASTHMA AND/OR ASTHMA SYMPTOMS AMONG HISPANICS IN THE UNITED STATES

Study (Reference)	Puerto Ricans (%)	Mexican Americans (%)	Cuban Americans (%)	Non-Hispanic Blacks/African Americans (%)	Non-Hispanic Whites (%)
Carter-Pokras and Gergen (6)*					
Lifetime asthma	20.1	4.5	8.8	9.1	6.4
Active asthma	11.2	2.7	5.2	5.9	3.3
Rodriguez and colleagues (38)†					
Lifetime asthma		7.8		10.2	9.3
Current asthma		5.2		7.8	6.7
David and colleagues (33)‡					
Lifetime asthma	19	6			12
Arif and colleagues (39)§					
Lifetime asthma		8.1		29.3	14.9
Current wheezing		11.1		25.4	19.5

* Survey of children participating in the Hispanic Health and Nutrition Examination Survey (HHANES) (1982–1984) and the National Health and Nutrition Examination Survey (NHANES) II (1976–1980). Lifetime asthma was defined as lifetime physician-diagnosed asthma. Active asthma was defined as current physician-diagnosed asthma.

† Survey of children participating in the NHANES III (1988–1994). Lifetime asthma was defined as lifetime physician-diagnosed asthma. Current asthma was defined as active physician-diagnosed asthma.

‡ Survey of women participating in the East Boston Childhood Respiratory Disease Cohort. Asthma was defined as lifetime physician-diagnosed asthma.

§ Survey of parents of children in the South Plains/Panhandle region of Texas. Asthma was defined as lifetime physician-diagnosed asthma.

of 9,992 children, estimates of the prevalence of lifetime physician-diagnosed asthma and active physician-diagnosed asthma were highest in Puerto Ricans and lowest in Mexican Americans (6). In a study of 1,319 schoolchildren in East Harlem (New York), current wheezing was significantly more common in Puerto Ricans (31.7%) than in members of other ethnic groups (20.4%) (31). A high prevalence of asthma among Puerto Rican children (32) and/or adults (32, 33) was also reported in studies conducted in East Boston (Massachusetts) (33) and Brooklyn (New York) (32). Two additional studies in the Bronx (New York) (34) and Connecticut (35) found that Hispanic children (most of whom were presumably Puerto Rican) had a higher prevalence of asthma than children from other ethnic groups.

Findings from several studies suggest that asthma is a common health problem in Puerto Rico. In a study of 3,000 children and adults interviewed at a shopping center in Ponce (southern Puerto Rico), estimates of the prevalence of lifetime asthma in individuals younger and older than 20 years were 25.1 and 13.1%, respectively (36). In a study in San Juan, current wheezing (41%) and active physician-diagnosed asthma (30.1%) were frequently reported by parents of 3,492 children (ages 4 to 7 years) (37). Among adults participating in the Behavioral Risk Factor Surveillance System in 2002, the prevalence of either lifetime (19.6%) or current (11.5%) asthma was higher in Puerto Rico than in any other state or territory of the United States (5).

In contrast to the findings in Puerto Ricans, several studies have reported a relatively low prevalence of asthma in Mexican Americans (Table 4). Among 12,388 children in the National Health and Nutrition Examination Survey (NHANES) III, active physician-diagnosed asthma was less frequently reported by Mexican Americans than by African Americans or non-Hispanic whites (38). In a study of 1,500 children in Texas, estimates of the prevalence of lifetime physician-diagnosed asthma and current wheezing were lower in Mexican Americans than in non-Hispanic whites or non-Hispanic blacks (39). Among 18,393 adults in NHANES III, estimates of the prevalence of current asthma and current wheezing were lower in Mexican Americans than in members of other ethnic groups (7).

There are limited data on the prevalence of asthma in Hispanics in the United States other than Puerto Ricans or Mexican Americans (*see also above*). Among 326 Hispanic women who were enrolled in a study in East Boston (Massachusetts) and whose country of birth was known, lifetime physician-diagnosed asthma was reported by 3% of Salvadorans, 3% of South Americans, 6% of Mexicans, and 19% of Puerto Ricans (Table 4) (33). In a survey of schoolchildren in Passaic (New Jersey), parental report of an asthma diagnosis was higher in Puerto Ricans than in Dominicans, regardless of health insurance coverage (40). Romero and coworkers examined the prevalence of chronic diseases in elderly individuals in Albuquerque (New Mexico) (41). Of 401 Hispanic subjects, more than 80% self-identified as bilingual, born in New Mexico or neighboring states, and Spanish-American (likely implying a long period of residence in the United States). Self-reported asthma was more common in non-Hispanic white men (9.3%) than in Hispanic men (4.2%, $p < 0.05$ for comparison). Similar results were obtained in a previous study in New Mexico that accounted for differences in tobacco use between non-Hispanic whites and Hispanics (42).

In summary, asthma is a common health problem in Puerto Ricans living in the U.S. mainland and Puerto Rico. In contrast, the prevalence of self-reported asthma is relatively low—but not negligible, given the large population size—in Mexican Americans. However, some underestimation of the true prevalence of asthma in Mexican Americans cannot be excluded in the absence of validation studies of questions on asthma in this ethnic group. Limited data are available on asthma prevalence in Hispanics other than Puerto Ricans or Mexican Americans.

MORBIDITY AND MORTALITY OF ASTHMA IN HISPANICS

Hispanic America

In the Asthma Insights and Reality in Latin America (AIRLA) survey, 46,275 households in 10 Hispanic-American nations and Brazil were screened to identify 808 children and 1,376 adults with asthma (43). Of the 2,184 participating subjects, 1,021 (46.8%) had mild intermittent asthma, 474 (21.7%) had mild persistent

asthma, 214 (9.8%) had moderate persistent asthma, and 475 (21.7%) had severe persistent asthma according to the Global Initiative for Asthma severity scale. Among study participants, 52% of adults and 69% of children had at least one asthma exacerbation (a hospitalization, a visit to the emergency department, or an unscheduled emergency visit to a physician) in the previous year. Report of a hospitalization for asthma in the previous year (22%) was higher than that shown in similar studies in Europe (44), the Asia-Pacific region (45), and North America (46).

In a population-based study in urban areas of Colombia, severe wheeze requiring an emergency department visit or a hospitalization in the previous year was reported by 6.3% of children and 4% of adults (23). In another study, the rate of emergency department visits for asthma among Mexicans ensured by the IMSS was substantially higher than that of the general U.S. population in 1999 (1, 30), whereas their rate of hospitalization was significantly lower. These findings may represent differences in asthma management and/or health care use for asthma between Mexican subjects ensured by the IMSS and individuals living in the United States.

There is significant variation in estimated asthma mortality rates among Hispanic-American nations (Table 1), where a significant proportion of deaths attributed to asthma may happen outside of a hospital setting (47). For example, one study estimated that 63.4 and 88% of estimated deaths due to asthma occurred at home in Argentina and Paraguay, respectively (47). The variation in asthma mortality rates among Hispanic-American countries is poorly understood but may be due to differences in access to health care, SES, asthma severity, asthma management, coding of asthma in death certificates, or a combination of these factors.

In summary, limited evidence suggests that asthma is a significant cause of morbidity in Hispanic America. The AIRLA survey was conducted in urban areas, and the frequency of non-participation among individuals approached for the survey was not reported. However, it is unlikely that asthma management would be better in rural than in urban areas of Latin America, and some of the study results were presented according to asthma severity. Published data on the AIRLA survey does not allow adequate comparisons of asthma morbidity across Hispanic-American nations. Asthma mortality is different among Hispanic-American countries.

United States

Several studies have examined asthma morbidity in Puerto Ricans and Mexican Americans in the U.S. mainland. From 1982 to 1986, the average annual rates of hospitalization for asthma (per 10,000 persons) among New York City residents ages 0 to 34 years were 12.2 in whites and 62.9 in Hispanics (most of whom were presumably Puerto Rican) (48). In contrast, the age-adjusted rate of hospitalization for asthma among Hispanics ages 0 to 64 years in California (predominantly of Mexican descent) was 13.0 per 10,000 persons in 1997 (49). Among subjects in the Genetics of Asthma in Latino Americans (GALA) study, Puerto Ricans had an earlier age of onset of asthma, lower FEV₁ and FEV₁/FVC, and a higher risk of lifetime hospitalizations for asthma and visits to the emergency department for asthma in the previous year than individuals of Mexican descent, even after adjustment for asthma severity (8). In another study, Ramsey and colleagues examined the relation between ethnicity and asthma severity among 438 children in an asthma care program in Hartford (Connecticut) (50). After adjustment for level of lung function, allergen sensitization, health insurance, and other covariates, Puerto Ricans had three times the odds of having severe persistent asthma as non-Hispanic whites.

Some of the reported differences in asthma morbidity and/or asthma severity between Puerto Ricans and other ethnic groups may be explained by differences in health care use (8, 48, 49) or differential patterns of referral by ethnicity (50). In addition, differences in FEV₁ between Puerto Ricans and individuals of Mexican descent must be interpreted cautiously in the absence of reference values for Puerto Ricans and potential residual confounding by height (8). However, it is unlikely that differences in health care use and/or other sources of bias fully account for the magnitude of the observed differences in asthma morbidity between Puerto Ricans and Mexican Americans or non-Hispanic whites (8, 48–50).

Few studies have examined asthma morbidity in individuals in Puerto Rico. Among 526 children and adults with asthma in Ponce (southern Puerto Rico) (36), 26.1% had hospitalizations and 56% had emergency visits for asthma in the previous year. Emergency department visits (11%) and hospitalizations (6.2%) were less frequently reported in 67,396 children and adults with asthma enrolled in a health maintenance organization in Puerto Rico between 1996 and 1997 (51). In that study, however, 28,737 (48.8%) of 58,887 subjects with asthma with medication coverage had at least one course of oral or intravenous corticosteroids. Thus, a significant proportion of individuals in both studies had frequent asthma exacerbations, and the discrepant findings with regard to urgent care or hospitalizations for asthma may reflect differences in quality of health care and/or overrepresentation of individuals with persistent asthma in the Ponce survey.

Current data suggest that Puerto Ricans living in the U.S. mainland have greater asthma mortality than non-Hispanic whites, Cuban Americans, and Mexican Americans (9, 48, 52). In a review of vital statistics data for the U.S. mainland from 1990 to 1995, the age-adjusted annual asthma mortality rates (per 1 million persons) were 40.9 in Puerto Ricans, 38.1 in non-Hispanic blacks, 15.8 in Cuban Americans, 14.7 in non-Hispanic whites, and 9.2 in Mexican Americans (9). The age-adjusted asthma mortality rate for Puerto Ricans and Cubans was highest in the U.S. Northeast; 81% of all asthma deaths in Puerto Ricans occurred in this region.

In summary, Puerto Ricans have substantial morbidity and mortality from asthma. Because Puerto Ricans are U.S. citizens, they have better access to health care than a significant proportion of Mexican Americans. For example, the proportion of children lacking health insurance was lower in Puerto Ricans (11.4%) than in Mexican Americans (30.4%) who participated in the National Health Interview Survey (NHIS; conducted from 1998 to 2001) (53). However, it is unlikely that the reported differences in asthma morbidity and—particularly—asthma mortality between Puerto Ricans and Mexican Americans or non-Hispanic whites are solely explained by differential patterns in health care use. Little is known about asthma morbidity in Hispanics other than Puerto Ricans or Mexican Americans.

POTENTIAL RISK FACTORS FOR ASTHMA IN HISPANICS

The Genetics of Asthma in Hispanics

Genetic ancestry. Race has been defined as a group of persons who are relatively homogeneous with respect to ancestry (54), and racial groups have been characterized by their primary continent of origin (55). Ethnicity is a construct defined by a shared social, linguistic, and cultural heritage (55, 56). The use of race and/or ethnicity in investigational studies has generated significant controversy (55–61). To the extent that an ethnic group defines an endogamous group that can be differentiated from other such groups, ethnicity can be useful in genetic studies (55). However, it is important to recognize that broad ethnic

categories do not reflect the fact that individuals within an ethnic group can have different and/or mixed racial heritage.

The term "Hispanic" refers to ethnicity in the broad sense and not race: Hispanics can be of any race. Although most Hispanics have variable proportions of Caucasian, Amerindian, and African ancestry (62–65), Amerindians (native peoples of the Caribbean and the Americas), Europeans, and Africans with minimal admixture with other ethnic groups live in various Hispanic-American countries (65).

There have been many studies of genetic admixture in Hispanic-American countries, differing in methodology and sample size (65). In most of Hispanic America, three groups entered into contact with each other in the 15th and 16th centuries and mixed over the next four to five centuries: Amerindians, Europeans (mostly, but not exclusively, Spaniards), and Africans. In urban Hispanic Americans, the proportion of European, Amerindian, and African ancestry varies among and within countries. In Mexico, ancestry has been estimated as 41% European, 56% Amerindian, and 3% African in Mexico City (66), and as 35% European, 39% Amerindian, and 26% African in Veracruz (a city on the Atlantic coast) (67). In Uruguay, ancestry was estimated as 90% European, 1% Amerindian, and 9% African in Montevideo (the country's capital), and as 65% European, 20% Amerindian, and 15% African in a northern city near Brazil (Tacuarembó) (68). Consistent with the fact that most early Spanish immigrants to America were men, several studies in Hispanic America (65, 69, 70) have reported greater (yet variable) European than Amerindian contribution on Y chromosomes but a greater Amerindian than European contribution on mitochondrial DNA (inherited almost exclusively from an individual's mother).

Although studies of genetic admixture in Hispanics in the United States are heterogeneous in methodology, their findings suggest that Puerto Ricans and Cubans have greater proportion of African ancestry but a lower proportion of Amerindian ancestry than Mexican Americans (63, 64, 71). For example, the relative average contribution of African ancestry has been estimated as 19.8% in Cubans, as ranging from 3.4 to 7.8% in Mexican Americans, and as ranging from 16.2 to 36.9% in Puerto Ricans; and the relative average contribution of Amerindian ancestry has been estimated as 18% in Cubans, as approximately 18% in Puerto Ricans, and as ranging from 31 to 51.7% in Mexican Americans (63, 64, 71).

Genetic Studies

In non-Hispanic populations, multiple studies have demonstrated a significant genetic contribution to asthma (72–82) and identified chromosomal regions that may contain susceptibility genes for asthma (83–102). More than 70 genes have been included in studies of genetic association for asthma or asthma-related phenotypes (101, 103–106), and five potential asthma-susceptibility genes have been identified by positional cloning (an approach involving genomewide linkage analyses followed by fine-mapping studies of association in linked genomic regions) (101, 104–109).

What are some of the potential uses of studying the genetics of asthma in Hispanic subgroups? First, rare asthma-susceptibility alleles (frequency $\leq 2\%$) may be present in only a few ethnic subgroups, and identification of such variants may benefit specific subgroups and lead to discovery of new disease pathways. Second, the frequency of asthma-susceptibility alleles may differ by ethnicity, and knowledge of these differences may be important in screening for and diagnosing asthma. Third, ethnicity may modify the effect of common asthma-susceptibility alleles through interaction(s) with genetic and/or environmental exposures. Knowledge of the proportion of asthma that is attributable to a particular allele(s) may be helpful in the prevention and manage-

ment of asthma in Hispanic subgroups. Fourth, studies of pharmacogenetics may identify genetic variants that influence response to and side effects from asthma therapy in Hispanic subgroups.

Although there are potential benefits as a result of conducting research studies on the genetics of asthma in Hispanic subgroups, there are also potential risks. For example, information from genetic studies of asthma could be used to restrict adequate access to health care and to avoid implementation of public health measures or social reforms to reduce exposure to detrimental environmental factors (e.g., improving housing conditions).

Relatively few studies of asthma genetics have included Hispanics. Only one genomewide linkage analysis for asthma, conducted by the Collaborative Study on the Genetics for Asthma (CSGA), included Hispanic individuals. Most Hispanic families in the CSGA came from an area of New Mexico where 38% of Hispanics self-identify as Mexican Americans and 60% of Hispanics self-identify as other Hispanic or Latino (110, 111). The initial genomewide linkage analysis of asthma in the CSGA included 48 Hispanics with asthma in 18 families (85). After inclusion of 12 additional Hispanic families, a repeat genomewide analysis found suggestive evidence of linkage (112) between chromosome 1p and asthma but no replication of earlier findings (95). Because of small sample size, this study had limited statistical power to detect linkage to asthma and/or asthma-related phenotypes (e.g., atopy) in Hispanics (96, 97).

Table 5 summarizes the results of selected candidate-gene association studies for asthma and/or asthma-related phenotypes in Hispanics. As is often the case in non-Hispanic populations, interpretation of these studies is limited by factors including small sample size (most common), (113–117), lack of information on environmental exposures (113, 116–120), and no adjustment for multiple comparisons (113, 119). In addition, problems inherent to genetic studies of asthma in Hispanics have not been adequately addressed, including inadequate definition of Hispanic subgroups (113, 114–116), heterogeneity of Hispanic participants with regard to country of origin and/or area of residence (114, 118, 120), and (for case-control studies) inadequate assessment of population stratification (a form of confounding by genetic admixture) (113, 115, 119). There has been no replication of positive findings in Hispanic subgroups in independent populations composed of members of the same subgroup.

To illustrate the challenges of interpreting genetic association studies in Hispanics, we will discuss results for the gene for the β_2 -adrenergic receptor (*ADRB2*). In non-Hispanic populations, many studies have found an association between variants in *ADRB2* and asthma-related phenotypes (e.g., response to inhaled β_2 -agonists) (121–137), but negative studies have also been reported, and the functional alleles responsible for the observed associations have not been confidently identified (131, 138). Santillán and colleagues found an inverse association between alleles (Glu27) and haplotypes (Gly16-Glu27) in *ADRB2* and asthma in adults with and without asthma in Monterrey (Mexico) (119). In the GALA study, there was an association between number of Arg16 alleles in *ADRB2* and increased bronchodilator responsiveness in Puerto Ricans with reduced lung function but no significant association between any single nucleotide polymorphism (SNP) in *ADRB2* and bronchodilator responsiveness in Mexicans after adjustment for multiple testing (120). The association between Arg16 alleles in *ADRB2* in Puerto Ricans is interesting and may explain differences in bronchodilator response between Puerto Ricans and individuals of Mexican descent (8). However, this association may be due to linkage disequilibrium (LD) with a functional allele(s) in/near *ADRB2* or chance (as there was no adjustment for multiple comparisons or replication of the findings in another Puerto Rican population). The discrepant reports for variants in *ADRB2* and asthma

TABLE 5. RESULTS OF SELECTED CANDIDATE-GENE ASSOCIATION STUDIES FOR ASTHMA AND/OR ASTHMA-RELATED PHENOTYPES IN HISPANICS

Gene	Reference	Study Population	No. SNPs Genotyped	Phenotypes	Results
<i>ADAM33</i>	113	Hispanics with (n = 112) and without (n = 126) asthma	8	Asthma Sensitization to allergens Total serum IgE	Association between SNPs in <i>ADAM33</i> and asthma and/or allergen sensitization
	118	Mexican (n = 265) and Puerto Rican (n = 318) nuclear families of individuals with asthma	6	Asthma Asthma severity Airway responsiveness Total serum IgE	No association
	114	Nuclear families of Hispanic children with asthma (n = 47)	17	Asthma Airway responsiveness FEV ₁ Total serum IgE	No association after adjustment for multiple comparisons
<i>ADRB2</i>	119	Mexicans with (n = 303) and without (n = 604) asthma	2	Asthma	Glu27 allele and Gly16-Glu27 haplotype were inversely associated with asthma
	120	Puerto Rican (n = 393) and Mexican (n = 274) families of individuals with asthma	8	Asthma severity Bronchodilator response Total serum IgE	Number of Arg16 alleles and homozygosity for Arg16/Gln27 haplotype were associated with increased bronchodilator response in Puerto Ricans with reduced lung function
<i>IL4/IL4RA</i>	116	Hispanic families of children with asthma (n = 30)	5	Asthma Sensitization to allergens	1 SNP in <i>IL4RA</i> was weakly associated with asthma
	115	Hispanics with (n = 116) and without (n = 130) asthma	11	Asthma Total serum IgE	2 SNPs were associated with total serum IgE but none was associated with asthma
<i>IL13</i>	117	83 Costa Rican nuclear families of children with asthma	1	Asthma Sensitization to allergens Total serum IgE	No association

Definition of abbreviations: *ADAM33* = a disintegrin and metalloprotease 33; *ADRB2* = β_2 -adrenergic receptor; *IL4* = interleukin 4; *IL4RA* = interleukin 4 receptor α chain; *IL13* = interleukin 13; SNP = single nucleotide polymorphism.

or asthma-related phenotypes in individuals of Mexican descent (119, 120) could be explained by differences in phenotypic assessment, population stratification in the case-control study (119), genetic and/or environmental heterogeneity in Mexicans in the GALA study (120), differential patterns of LD between study populations, chance (119), or inadequate statistical power (120).

Few studies have examined gene-by-environment and/or gene-by-gene interactions in Hispanics. An inverse association between an SNP (+1437 G/C) in the gene for monocyte differentiation antigen CD14 (*CD14*) and baseline FEV₁ was reported in Mexican and Puerto Rican families of persons with asthma who were reportedly exposed to parental smoking in infancy (139). In these families, the T allele of another SNP in *CD14* (−159 C/T) was associated with lower total serum IgE. In another study, Mexican children with a common homozygous deletion polymorphism of the gene for glutathione S-transferase (*GSTMI* null; n = 29) showed a greater reduction in midflow expiratory rates after ozone exposure than those without (n = 49) (140). A subsequent study of families of Mexican children with asthma and high ozone exposure found an inverse association between asthma and the serine allele of the Pro187Ser polymorphism of the *NQO1* gene (nicotinamide adenine dinucleotide [phosphate] reduced: quinone oxidoreductase) only in children who were *GSTMI* null (141).

As is often the case for studies of gene-by-environment and/or gene-by-gene interaction in non-Hispanics, interpretation of such studies in Hispanics is limited by small sample size (140, 141), cross-sectional design (139), nontesting for statistical interactions between genetic and environmental factors (139, 140), lack of correction for multiple comparisons (139–141), and limited assessment of environmental exposures (139, 141). Replication of the findings of these studies would help assess their biological significance.

In summary, most—but not all—Hispanics have variable proportions of European, Amerindian, and African ancestry. Lim-

ited inclusion of Hispanics in genetic studies of asthma may prevent this ethnic group from fully participating in advances in asthma diagnosis and therapy related to the genomic revolution. Interpretation of available genetic studies of asthma in Hispanics is limited by factors including poor characterization of Hispanic subgroups, small sample size, and lack of adjustment for population stratification resulting from genetic admixture.

SES and Asthma in Hispanics

SES can be assessed at the level of an individual (e.g., education, household income) (142) and the community where he/she lives (e.g., levels of poverty, substandard housing, violence) (143, 144). Multiple indicators exist for each component of SES, each with its advantages and disadvantages. The relation between SES and asthma is complex, with reports of direct (143, 145), inverse (146), or no association (147) between low SES and asthma, depending on the population studied.

Hispanic America. SES is a marker for exposures and conditions that vary among and within Hispanic-American nations. In many of these countries, low SES is inversely associated with adequate health care, nutrition, and sanitary conditions; and positively associated with infectious illnesses and overcrowding (148, 149).

An ecologic study examined the relation between gross national product (GNP) per capita and asthma prevalence in childhood (150). Of eight Hispanic-American countries, five were in the second quartile (\$1,490–\$3,170) and three were in the third quartile (\$3,610–\$17,500) of GNP per capita. In these countries, the median prevalence of current wheeze in adolescents was inversely associated with GNP per capita. However, GNP per capita is a gross measure of SES not necessarily correlated with adequate health care. For example, Costa Rica provides universal access to health care to its citizens but was classified in the second quartile of GNP per capita.

Few studies have examined the relation between SES and asthma in individuals in Hispanic America. Among Costa Rican children, parental education no higher than high school was associated with a threefold increase in the odds of asthma (95% confidence interval [CI] for odds ratio [OR], 1.4–6.4) in a multivariate analysis (151). Among poor children in rural Ecuador, extreme poverty was inversely associated with atopy after adjustment for helminthiasis and overcrowding (149). However, there was no report of the relation between SES and asthma (25).

In summary, little is known about SES and asthma in Hispanic America. Limited evidence suggests that the relation between SES and asthma in Costa Rica (a relatively prosperous nation) is similar to that observed in the United States.

United States. Poverty, a common condition in certain Hispanic subgroups (16, 152), has been associated with increased risks of asthma (7, 39, 143, 153), asthma morbidity (48, 154–156), and asthma mortality (52) among children and adults in the U.S. mainland, particularly in urban areas. In the United States, poverty is a surrogate for environmental risk factors for asthma (e.g., parental smoking) (157), asthma morbidity (e.g., cockroach allergen exposure) (158), and inadequate access to health care (142).

Several studies have examined whether the relation between Puerto Rican ethnicity and asthma is explained by SES (31, 32, 35). In a study of 2,864 Hispanics living in a neighborhood of Brooklyn (New York), Dominicans ($n = 1,566$) and other Latinos ($n = 183$) had 60% lower odds of asthma than Puerto Ricans (32), a finding that was unchanged after adjustment by health insurance, educational level, or country where education was completed. Among 1,319 children in East Harlem (New York), Puerto Rican ethnicity was associated with a twofold increase in the odds of asthma that was not explained by parental education or annual household income (31). Among 4,206 adults in Puerto Rico, low educational attainment and lack of health insurance were both associated with a 30% reduction in the odds of lifetime asthma (diagnosed by a health professional) (159). However, it is unclear whether these findings are explained by inadequate health care due to lack of information on asthma symptoms. In a study of children attending public ($n = 2,849$) and private ($n = 678$) schools in San Juan, there was no association between type of school attended (a proxy for SES in Puerto Rico) and lifetime physician-diagnosed asthma or current asthma symptoms (37). However, children in public schools had a higher prevalence of active physician-diagnosed asthma (31.6 vs. 23.7%, $p < 0.01$) and greater asthma morbidity than children in private schools.

Large studies of children and adults have shown that Mexican-American ethnicity is associated with lower risks of asthma and wheezing independent of parental education and other indicators of SES (7, 39).

In summary, poverty has been associated with an increased risk of asthma and asthma morbidity in the United States, and vigorous efforts to reduce disparities in asthma care by SES should continue for Hispanics and non-Hispanics alike. However, poverty is unlikely to be the sole explanation for the increased burden of asthma in Puerto Ricans and fails to explain the relatively low prevalence of asthma in Mexican Americans.

Air Pollution

Degree of atmospheric pollution was poorly correlated with asthma prevalence in phase I of ISAAC in Hispanic America (18). In non-Hispanic populations, there is insufficient evidence of a causal association between outdoor air pollution and asthma but adequate evidence of an association between outdoor air pollution and increased asthma morbidity (160, 161).

Mexico City is one of the most polluted cities in the world. Among children in Mexico City, exposure to ozone (162–165)

and/or particulate matter (163) has been associated with reduced lung function (162), respiratory symptoms (162, 163), emergency department visits for asthma (164), and school absences for respiratory illnesses (165). In a study of 71 children with mild asthma monitored for 2 months, high levels of particulate matter less than $10 \mu\text{m}$ (PM_{10}) were inversely associated with peak flow rate and directly associated with respiratory symptoms (163), and a 50-ppb increase in daily 1-hour maximum ambient ozone level was associated with a 9% increase in total respiratory symptoms. In a randomized clinical trial of the effects of antioxidants (vitamin E and vitamin C) on ozone-related changes in lung function in Mexico City, 158 children with asthma were monitored for 16 months (166). In 82 children with moderate to severe asthma, ozone levels 1 day before spirometry were inversely associated with FEV_1 ($-4.59 \text{ ml}/10 \text{ ppb}$, $p = 0.04$) and peak expiratory flow in the placebo group but not in the antioxidant group, suggesting that antioxidants protect against detrimental effects of ozone exposure on Mexican children with nonmild asthma.

A few studies have examined the relation between air pollution and asthma in Hispanic-American cities with lower levels of air pollution than Mexico City. Increased levels of PM_{10} have been associated with increased risks of emergency department visits for asthma in Ciudad Juárez (Mexico) and Havana (Cuba) (167, 168), wheezing bronchitis in infants in Santiago (Chile) (169), and hospitalizations for asthma in southern Puerto Rico (170).

Little is known about the relation between indoor exposure to wood smoke from cooking and asthma in rural Hispanic America. Among Amerindian children in an area of Guatemala with low prevalence of smoking, use of open fires for cooking was associated with a threefold increase in the odds of current wheezing in an analysis that did not adjust for indicators of SES and other potentially relevant covariates (26).

Interpretation of most available studies of air pollution and asthma morbidity in Hispanic America is limited by an ecologic and/or cross-sectional design, small sample size, lack of assessment of individual exposure, nonassessment of other risk factors for asthma morbidity (e.g., outdoor allergens) (171), and limited phenotypic assessment of asthma. However, current evidence suggests that exposure to high levels of ozone and/or particulate matter is associated with increased asthma morbidity in some Hispanic-American cities. There have been no studies of air pollution and asthma or asthma morbidity in Hispanic subgroups in the United States.

Passive Exposure to Smoking

In non-Hispanic populations, ETS exposure is associated with increased risks of asthma and asthma morbidity in childhood (172–174) through mechanisms that are incompletely understood.

Few studies have examined the relation between ETS exposure and asthma or asthma morbidity in Hispanic America. Among Costa Rican schoolchildren, there was a strong but non-significant association between maternal smoking during pregnancy and current asthma (OR, 6.9; 95% CI, 0.8–60.0) in analyses adjusting for parental education and other covariates (151). In a study in Ciudad Juárez (Mexico), ETS exposure in infancy was associated with a 35% increase in the odds of current wheezing at school age (20). Similar findings were reported for children in the state of Guerrero (Mexico) (22).

Cigarette smoking is common in Hispanics living in the United States. Among 8,882 Hispanics in the United States, current smoking was reported in 25% of men and 12.1% of women (175). Among Hispanic men, current smoking did not differ by national origin, but Puerto Ricans and Cubans were more likely to be heavy smokers than Mexican Americans. Among Hispanic women, current and heavy cigarette smoking were less common in Mexican Americans than in Puerto Ricans or Cuban Americans.

Few studies have examined ETS exposure and asthma in Hispanic subgroups in the United States. In a study of childhood asthma in Connecticut, Hispanics (predominantly Puerto Rican) had higher odds of lifetime physician-diagnosed asthma than non-Hispanic whites after adjustment for current ETS exposure at home (35). In an analysis restricted to Hispanics, there was no association between current ETS exposure and asthma. Among Puerto Rican children in East Harlem (New York), current ETS exposure at home was less common in those with asthma than in those without, a finding that may be explained by avoidance of indoor smoking by parents of children with asthma (31). In a study of schoolchildren in New Jersey, current ETS exposure was associated with increased odds of school absences for asthma in Puerto Ricans (40). In addition, there were associations of borderline significance ($p = 0.05$) between current ETS exposure and lifetime asthma in Puerto Ricans and Dominicans. In a study of 78 Hispanic (predominantly Mexican-American) children with moderate to severe asthma, current ETS exposure at home had a negative impact on the daily activities of participating children and their families (176). Among 486 individuals with asthma in Puerto Rico, avoidance of ETS exposure was associated with decreased odds of emergency department visits for asthma (177).

In summary, little is known about ETS exposure and asthma in Hispanics living in Hispanic America or the United States. Major limitations of published studies include cross-sectional design, nonobjective measurements of ETS exposure, limited statistical power, and/or inadequate adjustment for potential confounders. Minimal evidence suggests that current ETS exposure is associated with asthma morbidity in Mexican Americans and Puerto Ricans. Limited evidence suggests that programs to reduce ETS exposure in urban Hispanic children with asthma in the United States can be successful (178, 179).

Obesity and Asthma in Hispanics

In non-Hispanic populations, obesity has been consistently associated with asthma (180–186) but not with airway responsiveness (180, 187–190) or atopy (190–193). Although bariatric surgery results in improvement of asthma symptoms in morbidly obese patients (194, 195), there have been no adequate clinical trials of weight loss and asthma. Thus, there is strong but not conclusive evidence to support a causal association between obesity and asthma. Considerable controversy remains as to potential mechanisms underlying this association (196, 197).

Obesity is a significant public health problem in Hispanic America, particularly in urban areas (198). Among 1,232 adults in a semirural area of Chile, a measure of overweight (body mass index [BMI]) was associated with current wheeze (OR, 1.04; 95% CI, 1.00–1.08) and airway hyperresponsiveness (OR, 0.92; 95% CI, 0.87–0.96) in women ($n = 675$) but not in men ($n = 556$) (199). Waist circumference (another measure of overweight) was not associated with current wheeze or airway hyperresponsiveness. Among 533 hospital workers in Mexico, waist circumference and BMI were associated with an increased risk of asthma symptoms in women ($n = 398$) but not in men ($n = 135$) (200). A third measure of overweight (waist-to-hip ratio) was not associated with asthma symptoms. In a study of adults with ($n = 303$) and without ($n = 659$) asthma in Monterrey (Mexico), obesity (BMI ≥ 30 kg/m²) was associated with a twofold increase in the odds of asthma in both men and women (201).

Obesity is a major health problem in Mexican Americans and Puerto Ricans. Among Mexican Americans participating in NHANES, 22.2% of children were overweight and 32.6% of adults were obese (202). In a study of 17,555 Mexican-American adults who participated in NHANES III ($n = 4,575$) and the NHIS ($n = 12,980$), obesity was associated with a near twofold increase in the odds of asthma among Mexican Americans in

the NHIS but not in the NHANES III (203), which may be explained by differences in assessment of BMI and sample size between studies. Among adults participating in the Behavioral Risk Factor Surveillance System in Puerto Rico in 2001, 22.9% were classified as obese (204). In that study, obesity was associated with increased odds of asthma (OR, 1.7; 95% CI, 1.4–2.1) in an unadjusted analysis (159).

In summary, a few studies have found an association between obesity and asthma in Chilean women, Mexicans, Mexican Americans, and Puerto Ricans. Interpretation of these studies is limited by their cross-sectional design (159, 199–201, 203), nonassessment of measures of obesity other than BMI (159, 201, 203), lack of information on intermediate asthma phenotypes (159, 200, 201, 203), inability to exclude selection bias and/or residual confounding by cigarette smoking (159, 199–201), and limited description of the definition of airway hyperresponsiveness (199).

Allergen Exposure, Allergen Sensitization, and Asthma in Hispanics

Atopy (often defined as sensitization to at least one allergen) is a strong risk factor for asthma in industrialized nations (205–208) but not in rural societies (209). Atopy is neither necessary nor sufficient for asthma causation. A significant proportion of individuals with asthma are nonatopic, and a large proportion of atopic individuals do not have asthma (210, 211).

Data from studies in predominantly non-Hispanic populations suggest that the relation between allergen exposure and asthma pathogenesis is dependent on the interaction between genetic factors and dose, timing, and type of allergen exposure. For example, indoor exposure to dust mite allergen in early life may influence the development of childhood asthma only at high levels (205, 212), and maternal history of asthma may modify the relation between early exposure to cat allergen and childhood asthma (213, 214). It is well accepted that sensitization to indoor allergens is associated with asthma and asthma morbidity and that allergen exposure is associated with asthma morbidity in sensitized individuals (215).

Hispanic America. Area of residence and helminthiasis may modify the relation between atopy and asthma in Hispanic America. In Costa Rica (a country with low prevalence of helminthiasis), childhood asthma was strongly associated with total serum IgE and atopy (216, 217). On the other hand, atopy was uncommon and not strongly associated with asthma or asthma symptoms among children in impoverished areas of Lima (Peru) and rural Ecuador (25, 218). Of 4,064 Ecuadorian children living in rural areas endemic for helminthiasis, only 741 (18.2%) were atopic (25). After adjustment for helminthiasis, the association between atopy and current wheezing was of similar magnitude to that observed in children in rural Africa (219).

A number of cross-sectional studies have examined indoor exposure to dust mite allergen in predominantly urban areas of Hispanic America (220–225). In one study, the mean values (SD) of the concentration of *Der p 1* in dust samples from the beds of Costa Rican children was 27.6 (3.9) μ g/g, with higher values detected in warm and humid areas (220). In a study of children in 10 countries in the Asia-Pacific region, the geometric mean concentration of total *Der p 1* in homes in a coastal Chilean city (Valdivia) was the second highest of all centers (222). Although interpretation of studies of indoor exposure to dust mite in Hispanic America is limited by relatively small sample sizes and differences in methodology, their findings suggest that exposure to high levels of dust mite allergen is common, particularly in coastal and/or tropical areas.

Few studies have examined exposure to allergens other than dust mite in Hispanic America. High concentrations of cockroach allergen were found in dust samples from the floor of the

bedrooms of Costa Rican children, particularly in coastal areas (mean [SD] for *Blatella germanica* 2 = 15.5 [16.4] U/g of dust) (220). An ecologic study found that high airborne concentrations of grass pollen and fungal spores were associated with increased odds of visits to one emergency department in Mexico City during the wet and dry seasons because of childhood asthma (171). Outdoor allergens were more strongly associated with emergency department visits for childhood asthma than measures of outdoor air pollution. Increased outdoor levels of pollen were associated with asthma exacerbations (226) and increased peak flow variability after the rainy season in two studies of Mexican children with atopic asthma that did not account for air pollution (227).

Many uncontrolled studies have found that sensitization to at least one species of dust mite is common yet of variable frequency among individuals with asthma and/or allergic diseases in Hispanic America (228–234). For example, sensitization to *Dermatophagoides farinae* among subjects with asthma ranged from 53.3% in Cordoba (Argentina) to 97.2% in Caracas (Venezuela) (230). In another study, sensitization to cockroach was very common in individuals with asthma attending allergy clinics in Caracas (Venezuela), particularly among the poor (229).

A few case-control studies have examined sensitization to specific allergens and asthma or asthma morbidity in Hispanic-American countries. Sensitization to house dust mite has been associated with asthma in an Andean city in Ecuador (Quito) (235) and in Costa Rica (151, 217) and with emergency department visits for asthma in a coastal city of Colombia (Cartagena) (236). In a multivariate analysis including 214 Costa Rican children, sensitization to dust mite (*Dermatophagoides pteronyssinus*) was associated with a twofold increase in the odds of asthma and a threefold increase in the odds of current wheezing (151, 217), and sensitization to *Alternaria tenuis* was associated with a threefold increase in the odds of current wheezing. Although several additional indoor (e.g., cockroach) and outdoor (e.g., mixed tree pollen) allergens were associated with asthma in bivariate analyses, these associations were nonstatistically significant after adjustment for covariates.

In summary, the relation between atopy and asthma in Hispanic-American countries may be modified by area of residence through factors that are not well understood. There is adequate evidence that exposure and sensitization to dust mite allergens is common in Hispanic America but little is known about exposure and sensitization to other allergens. There have been no prospective studies of the relation between allergen exposure and/or allergen sensitization and asthma in Hispanic America.

United States. Allergens of cockroach, dust mite, dog, cat, and rodents are found in variable concentrations in homes in the United States, where most children spend an average of 20 hours/day. (237) Few studies have examined the relation between allergen exposure and Hispanic ethnicity in the United States.

In the U.S. Northeast, studies of households of children with asthma or at risk for asthma have found that Hispanic ethnicity is positively associated with cockroach allergen exposure; negatively associated with exposure to allergens from cat, dog, and dust mite; and not associated with mouse allergen exposure (238–240), independent of indicators of SES, dwelling type, and other covariates. In contrast to the findings for dust mite allergen in the U.S. Northeast, a nationwide random survey of dust mite allergen concentrations in the beds of U.S. homes found no association between Hispanic ethnicity and dust mite allergen exposure (241). In a study of 172 economically disadvantaged infants at risk for asthma in Denver (Colorado), cat allergen levels from global house dust samples were lower in low-acclimated Hispanics (predominantly of Mexican descent) than in high-

acculturated Hispanics (predominantly of Mexican descent), African Americans, or non-Hispanic whites (242). However, there was no adjustment for SES and other covariates.

Few studies, limited by nonmeasurement of allergen levels (31, 40) or nonrandom selection of study participants (243), have examined the relation between indoor allergen exposure and asthma and/or asthma morbidity in specific Hispanic subgroups. Among 459 Puerto Rican children in East Harlem (New York), sighting mice or rats was associated with an increased risk of asthma after adjustment for reported exposure to cockroaches and other covariates (31). In a study of schoolchildren in Passaic (New Jersey), reported exposure to cockroaches was associated with asthma and school absences in Puerto Ricans and with school absences in Mexican Americans (40). In that study, report of bathroom mold was associated with asthma in Puerto Ricans and with school absences in Puerto Ricans and Mexican Americans.

In contrast to reports of a low prevalence of asthma in Mexican Americans, atopy is common in Mexican-American children. Among 1,546 Mexican-American children in a population-based study of allergen sensitization, sensitization to at least one indoor allergen (43%), dust mite (24%), cockroach (25%), and cat dander (12%) were common (244). After adjustment for poverty/income ratio, area of residence, and other covariates, Mexican Americans were more likely to be sensitized to dust mite and cockroach than whites. In a small study of children with asthma, sensitization to dust mite (39%) and cockroach (22%) was common in Hispanics (predominantly Mexican American) with asthma in urban San Diego (245).

Few studies have examined allergen sensitization in Puerto Ricans with and without asthma. In a study in southern Puerto Rico, sensitization to at least one allergen was more common in subjects with (85.8%) than in those without (52.5%) asthma (age-adjusted OR, 3.4; 95% CI, 2.3–5.0) (246). After adjustment for age, individuals with asthma had significantly higher odds of sensitization to at least one mite species, mold, cockroach, dog dander, or any pollen than those without asthma. However, nonrandom selection of individuals with and without asthma likely led to an overestimation of the magnitude of the observed associations. Among 312 Puerto Rican children with asthma in Hartford (Connecticut) (247), sensitization to dust mite (44.9%), cockroach (29.5%), cat dander (33.7%), and mixed grass pollen (17.6%) were all common. After adjustment for asthma severity and other covariates, Puerto Rican children with asthma were more likely to be sensitized to each of four allergens (cockroach, dust mite, grass pollen, and mugwort/sage) and less likely to be sensitized to dog dander than white children with asthma. Although differential patterns of referral by ethnicity may partially explain the study findings, the results were unchanged after adjustment for asthma severity and are consistent with other reports (248, 249) suggesting that allergy is underdiagnosed in ethnic minority groups. Among 466 subjects with atopic asthma (likely moderate to severe) in Ponce (Puerto Rico), 94.2% of study participants were sensitized to at least one of the following allergens: dust mite, dog, cat, or cockroach (250).

In summary, the generalizability and/or interpretability of studies of allergen exposure in Hispanics in the United States is limited by nonrandom selection of the study populations (238–240, 242), small sample size (251), and inadequate characterization of Hispanic subgroups (238, 240, 251). However, current evidence suggests that Hispanics are more likely to be exposed to cockroach allergen and less likely to be exposed to allergens from dust mite and pets than non-Hispanic whites in the U.S. Northeast. The reasons for this finding are incompletely understood but may reflect residual confounding by housing characteristics and/or behavioral and cultural differences among ethnic

groups. There are inadequate data on allergen exposure in Hispanic subgroups, and little is known about patterns of allergen sensitization in Puerto Ricans in nonselected populations. Limited evidence suggests that atopy is common in Mexican Americans and Puerto Ricans with asthma. There have been no prospective studies of the relation between allergen exposure and asthma in Hispanic subgroups in the United States.

Parasitic Infection and Asthma in Hispanics

Results of studies in non-Hispanic populations suggest that the relation between parasitic infections and atopy is influenced by host factors; the type, timing, and intensity of parasitic infestation; and other environmental exposures (219, 252–259). There are conflicting findings with regard to parasitic infections and asthma.

Several studies have examined the relation between helminthiasis and atopy in Hispanic America. In children and adolescents in rural Ecuador (25), active and chronic helminthiasis and intensity of helminthic infection were inversely associated with atopy (260). Among 107 Venezuelan children in a poor urban area, antihelminthic treatment for 22 months resulted in almost complete eradication of parasitism but increased prevalence of allergy to house dust (261). Of interest, reversible suppression of allergen sensitization by helminthiasis was shown in a recent clinical trial in Gabon (Africa) (262). Findings of studies in Venezuela and Ecuador suggest that an inverse association between ascariasis and atopy may be partly explained by protective effects of atopy against infection with *Ascaris lumbricoides* (263, 264).

A few studies have examined helminthiasis and asthma or asthma morbidity in Hispanic America (25, 265, 266). In rural Ecuador, helminthiasis was inversely associated with exercise-induced wheeze but not with any other asthma symptom (25). Among 39 children with asthma in Coche Island (Venezuela), antihelminthic treatment for 1 year resulted in a 2-year reduction in asthma attacks and medication use but no significant change in pulmonary function (266). There was no significant change in asthma morbidity over time in a comparison group of children who declined treatment.

In summary, current evidence supports an inverse association between helminthiasis and atopy in areas of Hispanic America with high prevalence of parasitic infections. In the absence of adequate prospective studies, it is not clear whether helminthiasis has a suppressive effect on allergic immune responses and/or whether atopy protects against helminthiasis. Interpretation of studies of the relation between helminthiasis and asthma or asthma morbidity in Hispanic America is limited by reduced statistical power due to small sample size (266) or low asthma prevalence (25), lack of assessment of intermediate asthma phenotypes other than atopy (25, 266), cross-sectional design (25), and lack of a proper control group (266).

Migration and Acculturation

Acculturation can be defined as the process of change by which immigrant groups try to adapt to host societies (267). Many measures and scales of acculturation exist, each with its advantages and disadvantages. Some proxy measures of acculturation include country of birth, age at immigration, and language of interview. In Hispanics in the United States, acculturation has been associated with potential risk factors for asthma and/or asthma morbidity, including increased exposure to ETS in infants of Mexican descent (242), increased prevalence of obesity in Puerto Rican women (268) and Mexican Americans (203), and increased prevalence of prematurity in Mexican Americans (267). On the other hand, acculturation has been associated with reduced odds of current smoking in men (175) and increased access to health care in Hispanics in the United States (267).

Two recent studies examined the relation between country of birth and asthma in Mexican Americans (203, 269). In a study of 17,555 Mexican-American adults, birth in the United States was associated with a twofold increase in the odds of lifetime physician-diagnosed asthma after adjustment for health insurance, source of medical care, citizenship status, language of interview, and other covariates (203, 269). Among Mexican Americans born in Mexico, those living in the United States for at least 10 years had half the prevalence of asthma as those living in the United States for less than 10 years (4 vs. 2%, $p < 0.01$), but this finding was not significant after adjustment for age. In a study of 4,121 Mexican-American children, birth in the United States was associated with a twofold increase in the odds of lifetime physician-diagnosed asthma after adjustment for source of care and other covariates (203, 269). In that study, birth in the United States was associated with a twofold increase in the odds of current wheezing only in children with history of ear infections. Among 1,652 children with allergy testing, those born in Mexico had higher odds of sensitization to cockroach but lower odds of sensitization to other allergens (e.g., dust mite) than those born in the United States.

In summary, acculturation may be associated with increased risk of asthma and atopy in Mexican Americans. However, recent findings must be interpreted cautiously because of lack of multivariate analyses of the relation between birthplace and current wheezing (203, 269), nonvalidation of questions on asthma in individuals of Mexican descent (203, 269), lack of analysis of the relation between birthplace and sensitization to at least one allergen (269), and inability to adequately exclude residual confounding and/or chance as alternative explanations for the observed results (269). Little is known about acculturation and asthma in Puerto Ricans living in the U.S. mainland.

DIAGNOSIS OF ASTHMA IN HISPANICS

Multiple factors may result in underdiagnosis of asthma in Hispanic America, including educational status of the general population, access to health care, training of health care providers with regard to asthma, reluctance of physicians to diagnose asthma for fear of stigmatization of affected individuals, and availability of diagnostic tests such as spirometry (270, 271). Findings from phase I of ISAAC indirectly suggest that asthma is underdiagnosed in young children in Hispanic-American nations because there are wide discrepancies among reports of current wheezing and ever-asthma (Table 2) that are not likely to be entirely explained by difficulty in making an asthma diagnosis in early childhood (10, 18, 272). However, there is limited objective evidence of potential underdiagnosis of asthma in Hispanic America. In particular, there have been no large studies of asthma assessed by methods other than questionnaire and few studies in impoverished and/or rural areas. Little is known about potential misclassification of chronic obstructive pulmonary disease as asthma, and vice versa, in adults in Hispanic America.

Few studies have examined whether asthma may be underdiagnosed in Hispanic subgroups in the U.S. mainland. In a survey of 8,743 children, current wheezing was reported in 10.7% of non-Hispanic whites and 16.3% of Puerto Ricans (273). In these children, lifetime asthma (diagnosed by a health care professional) was reported in 11.3% of non-Hispanic whites and 29.4% of Puerto Ricans. Compared with non-Hispanic whites with current wheezing, Puerto Ricans with current wheezing had 42% increased odds of lifetime asthma after adjustment for activity limitation and other covariates. These findings agree with those of previous studies (31, 37) and support a high prevalence of asthma in Puerto Ricans. The greater likelihood of an asthma diagnosis in Puerto Ricans than in non-Hispanic whites is likely

explained by differences in asthma severity between these two ethnic groups. However, overdiagnosis of asthma in Puerto Ricans cannot be excluded without objective assessments of asthma and/or asthma severity (e.g., lung function).

In contrast to the findings in Puerto Ricans, a discrepancy between current wheezing and an asthma diagnosis has been reported in most (7, 38, 39, 203) but not all (273) surveys of Mexican Americans. Among children with probable asthma who attended schools in an impoverished area of San Diego, only 57.4% of Hispanics (predominantly Mexican American) had been diagnosed with asthma by a physician (274). In contrast, approximately 80% of African-American children with probable asthma had been diagnosed with asthma by a physician. These findings provide limited evidence that asthma is underdiagnosed in Mexican Americans, probably because of reduced access to or use of health care, language or cultural barriers, or a combination of these factors (274, 275).

Reference values for spirometric measurements used for asthma diagnosis should ideally be calculated for specific ethnic groups living in a defined geographic area (276, 277). Pérez-Padilla and colleagues developed predictive equations for FEV₁ and FVC in 4,009 nonsmoking Mexicans ages 8 to 20 years in Mexico City (278). The mean spirometric values in participating subjects were approximately 5 to 6% higher than those predicted using equations developed from data in Mexican Americans of the same age, height, and sex (279), which may be explained by a higher trunk-to-leg ratio in Mexicans in Mexico City than in Mexican Americans. Similar results were obtained in a retrospective study of Mexican workers who had spirometric testing for work-related disability (280).

Gutierrez and coworkers developed predicting equations for mean spirometric values in 850 Chilean children and adults (281). Application of predicting equations of spirometric values for non-Hispanic whites in the United States (282) to Chileans of the same age and height resulted in underestimation of mean spirometric values by approximately 9 to 18% (281). Although a subsequent retrospective study found that implementation of reference values for Chileans (281) may result in overdiagnosis of mild airflow obstruction in children referred for spirometry (283), it is not clear whether that finding reflects lack of precision of the proposed reference values or inadequacies in the scheme used to define airflow obstruction. Attempts to develop reference spirometric values for other populations in Hispanic America (284–286) have been hampered by small sample size and/or nonrandom selection of study populations.

In the United States, Hankinson and colleagues developed spirometric reference values for non-Hispanic whites, African Americans, and Mexican Americans in NHANES III (279). After adjustment for age and height, Mexican Americans and non-Hispanic whites had similar mean FEV₁ and FVC values. The predicted mean FEV₁ values for Mexican Americans were similar to or slightly higher than those calculated using reference equations for Hispanics living in New Mexico (111) and Hispanics in Utah/California (287).

Coultas and colleagues developed prediction equations for spirometric measures in Hispanics in New Mexico from data obtained in 576 children and adults (111). Three prediction equations for spirometric measures in whites (282, 288, 289) overestimated reference spirometric values for Hispanics. In a subsequent study, spirometric values were categorized as normal or abnormal according to “internal” reference values for Hispanics in New Mexico and “external” reference values for non-Hispanic whites (290). Categorization of spirometric values as normal or abnormal was influenced by the choice of prediction equation in 5 to 10% of subjects.

In summary, there are limited data on the accuracy of asthma diagnosis among Hispanics in the United States and Hispanic America. The use of spirometric reference values developed for ethnic groups in the United States may result in underestimation of predicted spirometric values in Mexicans and Chileans. Adequate reference spirometric values are available for Mexican Americans and Hispanics from New Mexico but not for Puerto Ricans (291).

ASTHMA MANAGEMENT IN HISPANICS

Hispanic America

The management and control of asthma in Hispanics and Brazilians were assessed in the AIRLA survey (43). Among study participants, nocturnal awakenings occurred at least once per week in 34% of children and 39% of adults; 79% of adults and 68% of children reported some limitation on their daily activities because of asthma; and 31% of adults and 58% of children had at least one absence from work or school in the previous year. A written action plan for asthma management was given to 38% of adults and 49% of children, and only 51% of adults and 38% of children had ever had pulmonary function testing. Among study participants, 37% were using antiinflammatory medications for asthma, fewer than 11% were using inhaled corticosteroids, and half thought that the condition underlying asthma could be treated. These findings are in agreement with similar surveys conducted in other areas of the world (44–46) and emphasize the need for improvement in asthma management, access to health care, and education of health care providers and patients in Hispanic-American countries.

United States

In 2003, nearly one-third of approximately 41.2 million individuals without health insurance coverage in the United States were Hispanic (292). Among non-Puerto Rican Hispanic immigrants in the United States, the estimated proportions of individuals without private or government-sponsored health insurance between 1997 and 1998 were 17% in Cubans, 36% in Dominicans, 55% in Salvadorans, and 55% in Mexicans (293). Among Hispanics in the United States who are not citizens, health insurance coverage is dependent on legal residency status (292). However, 45% of Hispanics who are legal residents of the United States are uninsured.

Freeman and colleagues examined the relation between health insurance and asthma among schoolchildren in Passaic (New Jersey) between 1998 and 2001 (275). In 1998, estimates of the proportion of insured children were 50% in Dominicans, 30% in Mexicans, 85% in Puerto Ricans, and 94% in non-Hispanic whites. From 1998 to 2001, there was a marked increase in health insurance coverage in non-Puerto Rican Hispanics due to implementation of state-run health insurance programs for children, with 81% of Dominicans and 65% of Mexicans having health insurance in 2001. Among all study participants, health insurance coverage was positively associated with diagnosis of and medication use for asthma. Although these results were consistent across ethnic subgroups, there was no multivariate analysis stratified by ethnicity.

Several studies that did not characterize Hispanic subgroups have examined whether factors other than health insurance coverage may result in inadequate management of asthma in Hispanics. Results of studies of subjects with asthma in managed-care organizations suggest that Hispanics are equally likely to be prescribed inhaled steroids but less likely to use inhaled steroids than non-Hispanic whites (294, 295), independent of SES and other potential confounders. In NHANES III, children from Spanish-speaking families were much more likely to be

inadequately treated for asthma than children from English-speaking families (OR, 64.6; 95% CI, 9.2–454.0), independent of poverty and health insurance (296).

Few studies have examined patterns of asthma management in Hispanic subgroups (8, 297, 298). In a study of 943 children with asthma in the U.S. Northeast, Hispanics (93% of whom were Puerto Rican) had 70% lower odds of using inhaled steroids than non-Hispanic whites, independent of health insurance and other covariates (298). In subjects with moderate to severe asthma in the GALA study, Puerto Ricans were more likely to use oral corticosteroids but less likely to use inhaled corticosteroids than individuals of Mexican descent (8). Puerto Ricans recruited in New York were less likely to use inhaled corticosteroids than those recruited in Puerto Rico (28.6 vs. 56.5%, $p < 0.01$), and individuals of Mexican descent recruited in San Francisco were less likely to use oral corticosteroids (6.6 vs. 20.2%, $p < 0.01$) than those recruited in Mexico City. Differences in medication use among ethnic groups and recruitment centers may reflect differences in educational status and asthma severity, as well as regional differences in asthma management practices and access to health care.

Recognition of differences in response to treatment among ethnic subgroups may be helpful in asthma management. In the GALA study, change in FEV₁ after administration of a bronchodilator (expressed as a binary or continuous variable) was higher in Mexicans than in Puerto Ricans, independent of asthma severity and other covariates (8). This finding could be explained by genetic factors (*see above*), unmeasured environmental exposures, and/or differential patterns of medication use by ethnicity.

Respect for and adequate response to a patient's normative cultural values (cultural competency) may lead to improved health care for asthma (299, 300). Although Hispanics share some beliefs about asthma, they are not a homogeneous group (301). In one study, Puerto Ricans, Mexicans, and Guatemalans—but not Mexican Americans—believed that exposure to cold weather could cause asthma (301); Mexicans and Guatemalans were more likely to report vitamins, prayer, and herbal remedies as potential therapies for asthma than Mexican Americans or Puerto Ricans. In a study of 118 Puerto Rican children with asthma in Hartford (Connecticut), use of asthma medications at home and use of home remedies were reported in 96 and 21% of study participants, respectively (302). Ethnomedical therapies (e.g., herbal remedies, magico-religious practices, and miscellaneous supportive treatments) were often used in combination with physician-directed treatment, and the majority of herbal remedies used for asthma were safe if used as directed. In an observational study of 1,663 Medicaid-ensured children with asthma (including 313 Hispanics) enrolled in managed care (300), cultural competence policies at practice sites were associated with increased use of antiinflammatory medications and higher quality of asthma care—but not with asthma exacerbations—in children with persistent asthma.

Few studies have examined the relation between Hispanic ethnicity and urgent care for asthma. Among 1,847 adults with emergency department visits for asthma in the United States and Canada (303), Hispanics ($n = 411$) had more severe airflow obstruction (assessed by peak flow measurements) and were more likely to report using the emergency department as their source of asthma care than whites. After adjustment for SES and other covariates, the difference in percent-predicted peak flow rates between Hispanics and whites was reduced but not eliminated. Although asthma management was similar in non-Hispanic whites and Hispanics, Hispanics were 2.6 times more likely to be hospitalized than whites. Interpretation of the findings of this study is limited by lack of characterization of Hispanic subgroups. In a recent retrospective study of 6,002 emergency

department visits for asthma in Ponce (Puerto Rico), there was limited documentation of oxygen saturation or peak flow rates (23.2%) or prescriptions for asthma (66.6%) (304). Most patients were treated with oral or intravenous corticosteroids, and aminophylline was used for asthma treatment in 1,333 (45.9%) of 2,906 adults.

Asthma management programs can be tailored to families, schools, health care providers, or the community. There is insufficient evidence to assess the effectiveness of family- or school-based educational interventions on asthma management in Hispanics (305, 306). Implementation of an asthma management program for primary care providers of poor urban children in Hartford resulted in increased use of antiinflammatory medications by primary care providers (from 38 to 96%) and reductions in the rates of emergency department visits (by $\sim 27\%$) and outpatient visits for asthma (by $\sim 19\%$) (307). Although the study was limited by absence of a proper control group, its findings suggest that a program focused on primary care providers of poor urban children with asthma (including Puerto Ricans) results in reduced asthma morbidity. In another study, implementation of a home-based environmental intervention aimed at reducing exposure to ETS and indoor allergens over a 1-year period resulted in reductions in allergen exposure and asthma morbidity in poor urban children with asthma ($\sim 40\%$ of whom were Hispanic) (179).

In summary, limited data suggest that there are inadequacies in asthma management and in the education of patients with asthma in Hispanic America. In the United States, lack of health insurance negatively influences asthma management in non-Puerto Rican Hispanics. However, factors other than noninsurance likely lead to inadequate asthma management in Hispanics in the United States, including language and cultural barriers that have been insufficiently studied (e.g., beliefs about asthma and its treatment, fear of side effects from corticosteroids, cultural competency of health care practitioners). Limited evidence suggests that Puerto Ricans are less likely to use inhaled corticosteroids than Mexican Americans. Recent findings suggest that community-based interventions may positively impact asthma management in poor urban children. However, little is known about the impact of such interventions in specific Hispanic subgroups.

FUTURE DIRECTIONS

Because of known diversity, studies of asthma in Hispanics should carefully characterize Hispanic subgroups by self-reported ethnicity, country of origin, place of birth, area of residence, and indicators of SES.

Future surveys of asthma prevalence in Hispanic America should be preceded or accompanied by validation studies and include individuals in rural areas. Assessment of the prevalence of intermediate phenotypes of asthma (e.g., airway responsiveness and atopy) in randomly selected populations would allow adequate validation of questions on asthma and asthma symptoms and help understand the relative importance of atopy as a factor contributing to asthma in Hispanic-American nations. Given limited financial resources for research in Hispanic America, well-conducted case-control studies of potential risk factors for asthma could generate valuable information. Current evidence suggests that modifiable risk factors for asthma and/or asthma morbidity, such as ETS exposure, obesity, allergen exposure, and access to health care are important and should be included in future studies of asthma in Hispanic America. In addition, studies of factors that may be more common or unique in certain regions of Hispanic America, including outdoor air pollution,

diet, helminthiasis, indoor exposure to wood smoke, and community violence (144), could provide valuable insight into the pathogenesis of asthma and asthma morbidity.

Studies of asthma genetics in Hispanics should include large samples of well-characterized Hispanic subgroups, have adequate information on relevant environmental exposures, and account for potential population stratification due to genetic admixture. The latter can be accomplished by using a family-based study design or methods to detect and adjust for population stratification (308, 309).

Among Hispanics in the U.S. mainland, little is known about factors explaining differences in asthma prevalence and asthma morbidity between Puerto Ricans and Mexican Americans. Factors that may explain these differences but that have been insufficiently studied include genetic variants, ETS exposure, housing characteristics, allergen exposure, diet, access to and use of anti-inflammatory medications and health care, and cultural beliefs. The rate of single motherhood is higher in Puerto Ricans than in Mexican Americans, and a plausible but untested hypothesis is that differences in family structure, community support, patterns of migration and acculturation, and community violence explain patterns of asthma and asthma morbidity in Puerto Ricans and Mexican Americans (16, 310). Other areas that need to be addressed in future research studies of asthma in Hispanics in the United States include validation of questions on asthma and asthma symptoms, development of reference values for spirometric measures in Puerto Ricans, obesity and asthma incidence, barriers to adequate asthma care other than health insurance, and cost-effectiveness of community-based interventions. Groups other than Mexican Americans or Puerto Ricans should be included in future studies of asthma in Hispanics in the United States.

The need for research on asthma in Hispanics should not supersede implementation of necessary and feasible measures to reduce asthma morbidity in this population. Current evidence strongly suggests that broadening access to health care, improving housing conditions, and reducing exposure to ETS and certain indoor allergens (e.g., cockroach) would have a significant positive impact on asthma morbidity in poor Hispanics.

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