

# Asthma Prevalence Among US Adults, 1998–2000: Role of Puerto Rican Ethnicity and Behavioral and Geographic Factors

Deborah Rose, PhD, David M. Mannino, MD, and Brian P. Leaderer, PhD, MPH

Most national-level studies of asthma risk factors in the United States have been limited to children,<sup>1,2</sup> and high asthma rates have been reported among Puerto Rican children living in the urban centers of the Northeast.<sup>3</sup> However, asthma incidence rates have increased in all age groups over the past 40 years.<sup>4,5</sup> Although the National Center for Health Statistics<sup>6–9</sup> and the Behavioral Risk Factor Surveillance System (BRFSS)<sup>10–12</sup> publish annual national estimates of asthma prevalence among US adults by age, race, and gender, to our knowledge, no studies have assessed the relevance of these factors, in combination, to asthma rates in a nationwide sample of adults.

We investigated several risk factors for asthma in adults that have been described in the literature: female gender,<sup>5,10,13</sup> Black race,<sup>5,10,12</sup> Puerto Rican ethnicity,<sup>14,15</sup> obesity,<sup>13,16,17</sup> poverty,<sup>10</sup> cigarette smoking,<sup>18</sup> urban residence,<sup>2,14</sup> health care use,<sup>1,5</sup> and exposure to environmental tobacco smoke (ETS).<sup>3,19</sup> Environmental exposures associated with asthma include mold, cockroaches, dust mites, gas stoves, and pets, but information on these risk factors was not available in our data set.<sup>3,19</sup>

Genetic factors,<sup>20</sup> including family health history<sup>21</sup> and gene–environment interactions,<sup>22</sup> are increasingly being included in research on asthma. A Connecticut study found a relative risk of 2.49 among children whose mothers had been diagnosed with asthma compared with children whose mothers had not been diagnosed for all race/ethnicity groups combined as well as for each group considered separately.<sup>3</sup> Because of the high prevalence of asthma among Puerto Ricans and the low prevalence reported among Mexican Americans,<sup>1</sup> the Genetics of Asthma in Latino Americans Study was initiated to investigate differences between these 2 groups in genetic susceptibility to asthma.<sup>23</sup>

**Objectives.** We analyzed asthma prevalence among US adults by age, gender, race, Puerto Rican ethnicity, and other demographic, behavioral, health, and geographic variables. We hypothesized that high prevalences would be observed among Puerto Ricans and in the Northeast census region.

**Methods.** We used data from the 1998 through 2000 US National Health Interview Surveys. Information on lifetime history of asthma and asthma in the past year was collected from 95 615 adults. We calculated weighted prevalence estimates and odds ratios from logistic regression.

**Results.** Of US adults, 8.9% had ever been diagnosed with asthma, and 3.4% had experienced an episode in the past 12 months. Asthma diagnosis rates were highest among Puerto Ricans (17.0%) and lowest among Mexican Americans (3.9%); rates were 9.6% and 9.2% among non-Hispanic Blacks and non-Hispanic Whites, respectively. Geographically, asthma prevalence was highest in the West (10.5%) and lowest in the Northeast (8.6%). Puerto Ricans in all regions had high asthma rates.

**Conclusions.** Significant variables in the final logistic regression model included race/ethnicity, obesity, poverty, female gender, and cigarette smoking. Higher asthma rates were confirmed among Puerto Ricans but not in the Northeast region. (*Am J Public Health.* 2006;96:880–888. doi:10.2105/AJPH.2004.050039)

Lara et al.<sup>24</sup> recommended that population-based surveys, such as the National Health Interview Survey (NHIS), be used to explore the relative importance of different asthma risk factors, including ethnicity, geography, socioeconomic status, and access to health care. In this study, we implemented that recommendation. Our goal was to provide national estimates of asthma prevalence among US adults as well as to analyze the relative contributions of demographic, geographic, socioeconomic, behavioral, environmental, and health care variables to elevated rates. We hypothesized that asthma prevalence would be higher among Puerto Ricans than among other racial and ethnic subgroups, higher in the Northeast region of the United States than in other regions, and higher in urban central cities than in less urban areas.

## METHODS

The NHIS is an annual national health survey in which personal interviews are

conducted in respondents' homes throughout the year. We used data collected during the 1998 through 2000 survey years. A complex, multistage design was used to select households, and the resulting weighted sample was representative of the civilian, noninstitutionalized population of the United States.<sup>25–27</sup>

Since 1997, at least 2 questions about asthma have been asked each year of 1 randomly sampled adult per family. Our study was based on information provided by 95 615 sample adults 18 years or older. Data were stored in several files that were combined to provide all of the available information for each respondent in 1 location. Birthplace and health insurance data were taken from the NHIS "person file," which includes information collected from all family members. Data on demographic and geographic variables, asthma diagnosis, access to health care, and health behaviors were obtained from the "sample adult file," which contains additional information collected only from the interviewed adult. In

1998 only, the sample adult was asked supplemental questions about ETS and other environmental variables. These variables were merged into the combined file from the separate 1998 “prevention file.”

The NHIS questions on race and ethnicity were asked in 2 stages. Respondents were first shown a list of Hispanic subgroups and asked whether they were of “Hispanic origin or ancestry.” The list of subgroups includes “Puerto Rican” and separate categories for “Mexican” and “Mexican American.”

Respondents were then shown a list of racial groups and asked to choose 1 or more to describe their racial makeup. In the 2000 census,<sup>28</sup> approximately 40% of Hispanics selected the “some other race” option; more than 20% did so in the 2000 NHIS. Respondents who reported multiple races in the NHIS were further asked to select a main race. If they picked 1, it was used in assigning an NHIS race code.

Our preliminary analyses indicated that 80% of those who chose “Mexican” were born in Mexico, and 80% of those who chose “Mexican American” were born in the United States, but Hispanic acculturation is a complex topic. Other studies also show that self-reports of ethnicity are not completely synonymous with country of birth.<sup>29</sup> We kept the Puerto Rican, Mexican American, and Mexican subgroups separate in our analyses, because asthma prevalence differed significantly among them. We combined the remaining Hispanic subgroups into the “other Hispanic” category because the sample sizes were small. Finally, for our analysis, we combined the separate Hispanic ethnicity and race variables into a single variable including 3 non-Hispanic subgroups (Black, White, other) and 4 Hispanic subgroups (Puerto Rican, Mexican American, Mexican, other Hispanic).

Between 1997 and 2000, the NHIS included at least 2 questions on asthma each year: “Have you ever been told by a doctor or other health professional that you had . . . asthma?” (lifetime asthma) and “During the past 12 months, have you had an episode of asthma or asthma attack?” (asthma in the past year). The question “Do you still have asthma?” was not added until 2001 and thus could not be included in our analysis.

**TABLE 1—Asthma Prevalence Among US Adults: National Health Interview Survey, 1998–2000**

	Unweighted No. (n = 95 615)	Ever Had Asthma, % (SE)	Had Asthma Episode in Past 12 Months, % (SE)
<b>Asthma prevalence</b>			
Ever had asthma	8 689	8.9 (0.12)	...
Asthma episode	3 486	...	3.4 (0.07)
<b>Survey year</b>			
1998	32 440	9.0 (0.18)	3.5 (0.11)
1999	30 801	8.5 (0.19)	3.4 (0.12)
2000	32 374	9.3 (0.19)	3.5 (0.12)
<b>Demographic variables</b>			
<b>Gender</b>			
Women	54 225	10.2 (0.16)	4.5 (0.11)
Men	41 390	7.6 (0.15)	2.2 (0.99)
<b>Age, y</b>			
18–44	49 272	9.5 (0.16)	3.6 (0.10)
45–65	27 827	8.7 (0.21)	3.5 (0.13)
≥ 65	18 516	7.6 (0.21)	2.7 (0.13)
<b>Place of birth</b>			
Puerto Rico	901	14.9 (1.35)	7.5 (0.90)
Foreign country	14 189	4.7 (0.21)	1.6 (0.12)
United States	80 426	9.5 (0.13)	3.7 (0.08)
<b>Ethnicity and race</b>			
Puerto Rican	1 659	17.0 (1.08)	9.2 (0.83)
Mexican American	3 839	7.5 (0.51)	3.0 (0.35)
Mexican	4 960	3.9 (0.33)	1.3 (0.19)
Other Hispanic	5 098	7.3 (0.43)	2.4 (0.24)
Non-Hispanic Black	13 131	9.6 (0.31)	3.6 (0.18)
Non-Hispanic Other	3 197	7.1 (0.57)	2.6 (0.31)
Non-Hispanic White	63 731	9.2 (0.14)	3.5 (0.09)
<b>Education</b>			
Not a high school graduate	20 011	9.4 (0.27)	3.8 (0.17)
High school graduate	27 842	8.4 (0.20)	3.2 (0.13)
Some college	26 192	10.0 (0.23)	3.8 (0.14)
College degree or above	20 620	8.1 (0.22)	3.0 (0.13)
<b>Poverty index</b>			
Below poverty level	11 230	12.2 (0.39)	5.5 (0.26)
100%–199% of poverty level	14 983	9.7 (0.31)	4.0 (0.19)
≥ 200% of poverty level	48 129	8.8 (0.16)	3.3 (0.10)
Unknown	21 273	7.5 (0.21)	2.7 (0.13)
<b>Health behavior variables</b>			
<b>Cigarette smoking status</b>			
Current smoker	22 337	9.9 (0.24)	3.7 (0.14)
Former smoker	21 278	10.0 (0.24)	3.8 (0.15)
Never smoked	51 138	8.1 (0.15)	3.2 (0.10)
<b>Alcohol use status</b>			
Current drinker	56 683	9.0 (0.15)	3.4 (0.09)
Former drinker	14 768	10.4 (0.27)	4.3 (0.18)
Lifetime nondrinker	22 507	7.9 (0.23)	3.0 (0.14)

Continued

TABLE 1—Continued

Body mass index, kg/m <sup>2</sup>			
≥ 30 (obese)	19 740	12.3 (0.27)	5.2 (0.18)
25–29.9 (overweight)	32 270	8.2 (0.19)	3.0 (0.11)
18.5–24.9 (normal weight)	38 021	8.0 (0.17)	2.9 (0.10)
< 18.5 (underweight)	2 071	8.7 (0.70)	3.7 (0.48)
Unknown	3 513	7.6 (0.50)	3.5 (0.34)
<b>Health care variables</b>			
Health insurance coverage			
Not covered	15 267	8.4 (0.28)	3.3 (0.17)
Covered	79 965	9.0 (0.13)	3.5 (0.08)
Most recent doctor visit			
≤ 6 months ago	64 394	10.5 (0.15)	4.3 (0.10)
> 6 months ago to 1 year	13 529	6.7 (0.25)	2.0 (0.14)
> 1 year ago or never	15 726	5.1 (0.21)	1.2 (0.10)
<b>Geographic variables</b>			
Census region of residence			
West	21 006	10.0 (0.27)	3.9 (0.15)
South	34 369	8.7 (0.19)	3.3 (0.12)
Midwest	22 178	8.8 (0.23)	3.3 (0.15)
Northeast	18 062	8.6 (0.27)	3.4 (0.17)
Area of residence			
MSA, central city	31 523	9.3 (0.19)	3.8 (0.14)
MSA, not central city	44 933	8.6 (0.16)	3.2 (0.10)
Non-MSA	19 159	9.2 (0.27)	3.6 (0.16)
<b>Environmental variables (1998 only)</b>			
Type of home			
Apartment or condominium	8 949	9.9 (0.36)	4.3 (0.25)
Single-family home	20 683	8.7 (0.22)	3.2 (0.14)
Trailer	1 979	9.9 (0.74)	4.1 (0.46)
Other	260	6.6 (1.75)	3.3 (1.26)
Home built before 1950			
Yes	9 576	8.8 (0.33)	3.8 (0.22)
No	19 662	9.1 (0.24)	3.3 (0.14)
Smoking in home			
Yes	8 875	9.8 (0.36)	3.8 (0.22)
No	22 886	8.8 (0.21)	3.3 (0.14)

Note. MSA = metropolitan statistical area. Percentages are weighted.

The health behavior variables we analyzed included cigarette smoking, alcohol use, and body mass index. Body mass index (weight in kilograms divided by height in meters squared) was calculated from self-reported height and weight (edited for extreme values), and the scores were grouped into the standard categories of underweight (less than 18.5 kg/m<sup>2</sup>), normal weight (18.5–24.9 kg/m<sup>2</sup>), overweight (25.0–29.9 kg/m<sup>2</sup>), and obese (30 kg/m<sup>2</sup> or higher). The health care variables included health insurance coverage and how long since

the respondent had last seen a doctor. In terms of geographic variables, we assessed respondents' region of residence (Northeast, Midwest, South, West) and whether they lived in (1) a metropolitan statistical area (MSA), (2) the central city of an MSA, (3) an MSA but not in the central city, or (4) a non-MSA. Environmental variables analyzed (for 1998 only) included type of housing, housing construction before 1950, and whether anyone smoked cigarettes, cigars, or pipes inside the home (ETS exposure).

We selected variables for analysis according to literature reviews and our previous research. Weighted descriptive analyses were carried out with SAS version 6.09.<sup>30</sup> MVS SAS-callable SUDAAN, PROC CROSSTABS, and PROC RLOGIST<sup>31</sup> were used to calculate prevalences and logistic regression odds ratios (ORs) after adjustment for the complex sample design. (In the LOGIST procedure, an iterative computational algorithm is used to test each variable as if it were the last one entered into the model.) All variables included in the final model were significant ( $P < .001$ ) with the exception of health insurance coverage, which was retained to account for differences in access to care. The sample adult weight was used in all analyses to adjust for the multistage sampling frame, oversampling according to race and ethnicity, and nonresponse according to age, gender, and race/ethnicity. We divided the weight by 3 to adjust for the 3 years of data.

In the NHIS, the geographic variables were assigned by the sampling frame, and there were no missing geographic data. For the remaining variables, the interviewer could assign a "don't know" or "unknown" response during the interview. "Not ascertained" was assigned during processing when an answer should have been provided but was not. If the combined nonresponse categories totaled 2% or less for a given variable, those records were dropped from the analysis. An "unknown" category was created for 2 variables, poverty index (22.2% missing data) and body mass index (3.6% missing data), so that these records could be retained in the analysis.

We used the CONTRAST option of the SUDAAN DESCRIPT procedure to conduct  $t$  tests of differences between unadjusted prevalences and the Wald F test to examine the logistic regression main effects. In assessing differences between adjusted prevalences, we used the  $t$  test option of the SUDAAN PROC LOGIST procedure to examine whether the logistic regression coefficients ( $\beta$  values) were significantly different from zero.

## RESULTS

### Weighted Prevalences

Between 1998 and 2000, 8.9% of adults in the civilian, noninstitutionalized population

**TABLE 2—Asthma Prevalence Among US Adults, by Census Region and Race/Ethnicity: National Health Interview Survey, 1998–2000**

Race/Ethnicity	Unweighted No.	Overall Prevalence, % (SE)	West, % (SE)	South, % (SE)	Midwest, % (SE)	Northeast, % (SE)
<b>Ever had asthma</b>						
All	95 615	8.9 (0.12)	10.0 (0.27)	8.7 (0.19)	8.8 (0.23)	8.6 (0.27)
Non-Hispanic Black	13 131	9.6 (0.31)	13.8 (1.37)	8.9 (0.41)	9.8 (0.63)	9.9 (0.73)
Non-Hispanic White	63 731	9.2 (0.14)	11.0 (0.34)	9.1 (0.24)	8.8 (0.25)	8.3 (0.32)
Hispanic	15 556	7.2 (0.26)	6.8 (0.38)	5.8 (0.43)	8.1 (0.98)	10.9 (0.72)
Non-Hispanic Other	3 197	7.1 (0.57)	8.7 (0.99)	6.9 (0.83)	5.7 (1.17)	4.7 (1.08)
Hispanic subgroups						
Puerto Rican	1 659	17.0 (1.08)	11.9 (2.98)	12.6 (2.37)	21.2 (4.09)	18.4 (1.36)
Mexican American	4 960	7.5 (0.51)	9.0 (0.78)	5.9 (0.70)	6.2 (1.67)	7.9 (7.67)
Mexican	3 839	3.9 (0.33)	4.5 (0.44)	2.7 (0.54)	4.0 (1.08)	2.1 (1.33)
Other Hispanic	5 098	7.3 (0.43)	8.4 (0.85)	6.8 (0.66)	11.2 (2.79)	6.3 (0.75)
<b>Had asthma episode in past 12 months</b>						
All	95 615	3.4 (0.07)	3.9 (0.15)	3.3 (0.12)	3.3 (0.15)	3.4 (0.17)
Non-Hispanic Black	13 131	3.6 (0.18)	6.3 (0.85)	3.2 (0.25)	3.4 (0.37)	3.7 (0.41)
Non-Hispanic White	63 731	3.5 (0.09)	4.4 (0.21)	3.4 (0.15)	3.3 (0.17)	3.3 (0.21)
Hispanic	15 556	2.9 (0.16)	2.5 (0.23)	2.3 (0.27)	3.0 (0.63)	5.0 (0.49)
Non-Hispanic Other	3 197	2.6 (0.31)	3.2 (0.55)	2.4 (0.46)	2.4 (0.77)	1.4 (0.56)
Hispanic subgroups						
Puerto Rican	1 659	9.2 (1.83)	4.6 (1.75)	8.7 (2.05)	10.4 (2.99)	9.6 (0.99)
Mexican American	4 960	3.0 (0.35)	3.6 (0.54)	2.4 (0.50)	2.0 (0.92)	0.0 (0.00)
Mexican	3 839	1.3 (0.19)	1.6 (0.29)	0.7 (0.17)	1.3 (0.61)	0.0 (0.00)
Other Hispanic	5 098	2.4 (0.24)	2.8 (0.49)	2.2 (0.37)	3.3 (1.58)	2.0 (0.38)

Note. Percentages are weighted.

of the United States reported having ever been diagnosed with asthma (Table 1). Lifetime asthma prevalence did not increase consistently over this 3-year period.

As hypothesized, lifetime asthma prevalence was significantly higher among Puerto Ricans (17.0%) than among any other racial/ethnic group ( $P < .001$ ) and significantly lower among Mexicans (3.9%) than among any other group ( $P < .001$ ). Prevalences among non-Hispanic Blacks (9.6%) and non-Hispanic Whites (9.2%) were not significantly different from each other ( $P = .148$ ). The prevalence among Mexicans was significantly lower than the prevalence among Mexican Americans (3.9% vs 7.5%;  $P < .001$ ).

Asthma in the past year showed the same pattern: rates were 9.2% among Puerto Ricans, 3.6% among non-Hispanic Blacks, 3.5% among non-Hispanic Whites, 3.0% among Mexican Americans, and 1.3% among

Mexicans (Table 1). In comparison with the other groups (in which rates ranged from 33% to 40%), a higher percentage of Puerto Ricans (54%) who had ever been diagnosed with asthma had also experienced asthma symptoms in the past 12 months ( $P < .001$ ).

In the NHIS, responses to questions on place of birth and ethnicity reflect different aspects of race/ethnicity. For example, approximately half of the respondents who indicated Puerto Rican ethnicity were born in Puerto Rico (49%) and approximately half were born in the United States (47.5%). Although lifetime asthma prevalences were not significantly different between these 2 groups (15.76% and 18.9%, respectively;  $P = .1726$ ), lifetime asthma prevalence was low (5%) among respondents born in Puerto Rico who did not claim Puerto Rican ethnicity. High rates of lifetime asthma were observed among female respondents, respondents at or below

the poverty level, former drinkers or smokers, obese respondents, and respondents who had visited a doctor in the past 6 months.

As can be seen in Table 1, asthma did not show a consistent increase or decrease with educational level or urbanization (i.e., the MSA variable). Lifetime asthma prevalence was significantly higher in the West (10.0%;  $P < .001$ ) and significantly lower in the Northeast (8.6%;  $P < .001$ ) than in the other regions combined.

Analyses in which race/ethnicity and geographic region were considered together showed that Puerto Ricans in all regions of the country had high rates for both asthma measures (Table 2). Puerto Ricans had the highest rates of any group in the South, Midwest, and Northeast regions. Although non-Hispanic Blacks living in the West region had higher rates than Puerto Ricans living in that region, the differences were not significant (13.8% vs 11.9%;  $P = .560$ , for lifetime asthma and 6.3% vs 4.6%;  $P = .380$ , for asthma in the past year).

Analyses of the environmental variables (1998 only) showed that the prevalence of lifetime asthma was higher among those living in an apartment or trailer than among those living in a single-family home (9.9% vs 8.7%;  $P = .011$ ); it was also higher among those exposed to smoking in the home than among those not exposed (9.8% vs 8.8%;  $P = .015$ ). Asthma prevalence was not affected by living in a home built before 1950 ( $P = .427$ ).

### Adjusted Multivariate Analyses

**Lifetime asthma.** To assess the relative importance of each of the factors under study, we ran logistic regression models in which lifetime asthma was the dependent variable and an array of sociodemographic, behavioral, geographic, and environmental factors served as the independent variables. The results of the adjusted analysis are shown in Table 3. Lifetime asthma prevalence increased only slightly between 1998 and 2000 (OR=0.94;  $P = .056$ ). With non-Hispanic Whites as the reference category, Puerto Ricans had the highest odds ratio of any racial/ethnic group (OR=1.87;  $P < .001$ ), whereas Mexican Americans (0.68) and Mexicans (0.56) had the lowest 2 odds ratios (both  $P < .001$ ). Rates among non-Hispanic Blacks were slightly lower than those among

**TABLE 3—US Adults Reporting Lifetime Asthma, National Health Interview Survey, 1998–2000: Results of Logistic Regression Analysis**

	Odds Ratio (95% Confidence Interval)	P Value for Wald F
Intercept	0.02 (0.02, 0.03)	<.001
Survey year		<.006
1998	0.94 (0.89, 1.00)	
1999	0.90 (0.84, 0.96)	
2000 <sup>a</sup>	1.00	
<b>Demographic variables</b>		
Gender		<.001
Women	1.32 (1.24, 1.39)	
Men <sup>a</sup>	1.00	
Age, y		<.001
18–44	1.60 (1.47, 1.73)	
45–65	1.27 (1.17, 1.38)	
≥ 65 <sup>a</sup>	1.00	
Place of birth		<.001
Puerto Rico	0.82 (0.61, 1.11)	
Foreign country	0.52 (0.45, 0.59)	
United States <sup>a</sup>	1.00	
Hispanic ethnicity and race		<.001
Puerto Rican	1.87 (1.49, 2.33)	
Mexican American	0.68 (0.59, 0.80)	
Mexican	0.56 (0.46, 0.69)	
Other Hispanic	1.04 (0.89, 1.22)	
Non-Hispanic Black	0.95 (0.87, 1.04)	
Non-Hispanic Other	1.05 (0.88, 1.25)	
Non-Hispanic White <sup>a</sup>	1.00	
Education		<.001
Not a high school graduate	1.21 (1.10, 1.33)	
High school graduate	1.00 (0.92, 1.08)	
Some college	1.14 (1.05, 1.23)	
College degree or above <sup>a</sup>	1.00	
Poverty index		<.001
Below poverty level	1.43 (1.31, 1.56)	
100%–199% of poverty level	1.15 (1.05, 1.25)	
≥ 200% of poverty level <sup>a</sup>	1.00	
Unknown	0.93 (0.86, 1.00)	
<b>Health behavior variables</b>		
Cigarette smoking status		<.001
Current smoker	1.18 (1.10, 1.26)	
Former smoker	1.25 (1.17, 1.35)	
Never smoked <sup>a</sup>	1.00	
Alcohol use status		<.001
Current drinker	1.08 (1.00, 1.17)	
Former drinker	1.20 (1.10, 1.30)	
Lifetime nondrinker <sup>a</sup>	1.00	

Continued

non-Hispanic Whites, but the difference was not significant (OR=0.95; *P*=.267).

The unadjusted, weighted lifetime asthma prevalence was high among respondents born in Puerto Rico (14.9%), but the odds ratio was low in the adjusted analysis, indicating that asthma was not significantly higher among those born in Puerto Rico than among those born in the United States (OR=0.82; *P*=.208). The low asthma prevalence among non-Puerto Ricans born in Puerto Rico (5.5%) may have accounted for this low odds ratio.

Other significant risk factors in the adjusted analysis included age (18–44 years vs 65 years or above; OR = 1.60), obesity (vs normal weight; OR = 1.57), living below the poverty level (vs living at 200% of the poverty level or above; OR = 1.43), living in the West region (vs the Northeast; OR = 1.33), female gender (OR = 1.32), having no high school diploma (vs having a college degree or above; OR = 1.21), being a former (OR = 1.25) or current (OR = 1.18) cigarette smoker (vs never having smoked), and being a former drinker (vs a nondrinker; OR = 1.20). All of these relationships were significant at *P*<.001.

In comparison with not having seen a doctor for a year or more, having visited a doctor within the past 6 months was strongly associated with ever having been diagnosed with asthma (OR = 2.05; *P*<.001). Although the unadjusted lifetime asthma rate was higher among respondents with health insurance coverage (9.0%) than among those with no coverage (8.4%), the adjusted odds ratio was not significant (1.05; *P*=.311).

Living in the central city of an MSA was a significant variable in the logistic regression (OR = 1.10; *P*=.016), whereas living in an MSA but not in the central city was not significant (OR = 1.0; *P*=.971). None of the 3 environmental variables available for the analysis of 1998 data (type of housing, home construction before 1950, and whether anyone smoked inside the home) were significant in the adjusted models.

*Asthma in the past year.* An adult respondent who reported a history of asthma but who did not report having an asthma episode or attack in the past year may have been successful in controlling the disease or may have had asthma only as a child. When we

TABLE 3—Continued

Body mass index, kg/m <sup>2</sup>		<.001
≥30 (obese)	1.57 (1.47, 1.68)	
25–29.9 (overweight)	1.11 (1.04, 1.18)	
18.5–24.9 (normal weight) <sup>a</sup>	1.00	
<18.5 (underweight)	0.99 (0.82, 1.18)	
Unknown	1.07 (0.91, 1.27)	
<b>Health care variables</b>		
Health insurance coverage		.311
Not covered	1.05 (0.96, 1.14)	
Covered <sup>a</sup>	1.00	
Most recent doctor visit		<.001
≤6 months ago	2.05 (1.87, 2.24)	
>6 months ago to 1 year	1.29 (1.14, 1.45)	
>1 year ago or never <sup>a</sup>	1.00	
<b>Geographic variables</b>		
Census region of residence		<.001
West	1.33 (1.21, 1.46)	
South	1.01 (0.92, 1.10)	
Midwest	0.98 (0.90, 1.08)	
Northeast <sup>a</sup>	1.00	
Area of residence		.005
MSA, central city	1.10 (1.02, 1.19)	
MSA, not central city	1.00 (0.93, 1.07)	
Non-MSA <sup>a</sup>	1.00	

Note. MSA = metropolitan statistical area.

<sup>a</sup>Reference category. For ordinal variables, the reference category was the highest or lowest category large enough to provide a stable comparison. For nominal variables, the reference category was selected on the basis of literature review and our expertise.

compared the logistic regressions for the 2 asthma outcomes, the odds ratios were higher for asthma in the past year than for lifetime asthma for most of the risk factors assessed (Table 4).

As with lifetime asthma, Puerto Ricans had the highest odds ratio of any racial/ethnic group for asthma in the past year (OR = 2.33;  $P < .001$ ) compared with non-Hispanic Whites. Other significant risk factors for asthma in the past year included being female, obese, young, poor, and a former drinker or smoker; having been born in the United States; and living in the West (all significant at  $P < .001$ ). Having seen a doctor within the past 6 months was strongly associated with past year asthma (OR = 3.23), but we lacked information on reasons for visits. As with lifetime asthma, lack of health insurance coverage was not a significant contributing factor to recent asthma (OR = 1.11;  $P = .125$ ). In addition, education level and

residence in an MSA did not show a linear relationship with recent asthma. Overall, there was no increase in the prevalence of recent asthma between 1998 and 2000 (OR = 0.98;  $P = .692$ ).

## DISCUSSION

Although many studies have assessed asthma prevalence rates among children,<sup>1</sup> adults in selected parts of the United States,<sup>3,14</sup> or adults in other countries,<sup>17,18</sup> this is the first study, to our knowledge, to analyze the prevalence of asthma and many associated risk factors among US adults nationwide (as recommended by Lara et al.<sup>24</sup>). Our results confirm those of smaller, more regional studies that included fewer variables.

### Demographic Factors

The results of this study confirm our hypothesis of very high asthma prevalences

among Puerto Ricans compared with other racial/ethnic groups.<sup>1,3</sup> Although NHIS and the BRFSS are not entirely comparable because the NHIS sampling frame does not include Puerto Rico, and the BRFSS does not report state-level asthma prevalences by Puerto Rican ethnicity, the 14.9% lifetime asthma prevalence we found among US respondents born in Puerto Rico was roughly comparable to the asthma prevalence of 15.9% seen among BRFSS respondents living in Puerto Rico.<sup>10</sup>

### Socioeconomic Status

The present results confirm our preliminary finding that when poverty was included in the analysis, Black adults did not have significantly more asthma than did White adults. In addition, our results show that poverty (OR = 1.43;  $P < .001$ ) was a more important risk factor than lack of education (OR = 1.21;  $P < .001$ ).<sup>2</sup>

### Geographic Factors

For all ethnic groups combined and for both measures of asthma, rates were highest in the West region and lowest in the Northeast region. Previous researchers studied populations in the urban Northeast because they displayed high asthma prevalences.<sup>3</sup> In the past, asthmatic patients were told to move to the Southwest because it lacked the air pollution and the plant allergens that exacerbated asthma. Because, over time, people brought trees and grasses from the East to the Southwest,<sup>32</sup> the former perceived advantage of living in the Southwest has diminished, and the prevalence of asthma is no longer highest in the Northeast. It is not clear why asthma prevalence rates are now highest in the West.

Although residence in an urban area is considered to be a risk factor for asthma among children,<sup>2</sup> our analysis did not show it to be a strong risk factor among adults. Living in a central city was the only urbanization factor that was significant in the 2 models presented in Tables 3 and 4.

### Personal Health Behaviors

Our results confirm that obesity<sup>16,17</sup> and cigarette smoking<sup>18</sup> are significant asthma risk factors among adults. The odds ratios for both asthma variables were higher among former smokers than current smokers. Although alcohol use and cigarette smoking are

**TABLE 4—US Adults Reporting Asthma in Past Year, National Health Interview Survey, 1998–2000: Results of Logistic Regression Analysis**

	Odds Ratio (95% Confidence Interval)	P Value for Wald F
Intercept	0.00 (0.00, 0.00)	<.001
Survey year		.828
1998	0.98 (0.89, 1.08)	
1999	0.97 (0.87, 1.07)	
2000 <sup>a</sup>	1.00	
<b>Demographic variables</b>		
Gender		<.001
Women	1.94 (1.77, 2.13)	
Men <sup>a</sup>	1.00	
Age, y		<.001
18–44	1.88 (1.65, 2.14)	
45–65	1.60 (1.40, 1.82)	
≥ 65 <sup>a</sup>	1.00	
Place of birth		<.001
Puerto Rico	0.72 (0.49, 1.07)	
Foreign country	0.50 (0.41, 0.63)	
United States <sup>a</sup>	1.00	
Hispanic ethnicity and race		<.001
Puerto Rican	2.33 (1.69, 3.20)	
Mexican American	0.67 (0.52, 0.86)	
Mexican	0.45 (0.32, 0.65)	
Other Hispanic	0.84 (0.66, 1.08)	
Non-Hispanic Black	0.83 (0.72, 0.94)	
Nnon-Hispanic Other	0.98 (0.75, 1.29)	
Non-Hispanic White <sup>a</sup>	1.00	
Education		.001
Not a high school graduate	1.29 (1.11, 1.50)	
High school graduate	0.99 (0.87, 1.12)	
Some college	1.13 (1.00, 1.27)	
College degree or above <sup>a</sup>	1.00	
Poverty index		<.001
Below poverty level	1.64 (1.44, 1.87)	
100%–199% of poverty level	1.28 (1.13, 1.45)	
200% of poverty level or above <sup>a</sup>	1.00	
Unknown	0.91 (0.81, 1.02)	
<b>Health behavior variables</b>		
Cigarette smoking status		<.001
Current smoker	1.11 (1.00, 1.24)	
Former smoker	1.23 (1.11, 1.36)	
Never smoked <sup>a</sup>	1.00	
Alcohol use status		<.001
Current drinker	1.18 (1.04, 1.33)	
Former drinker	1.36 (1.20, 1.54)	
Lifetime nondrinker <sup>a</sup>	1.00	

Continued

correlated behaviors,<sup>33</sup> in our study alcohol remained a significant factor for asthma even after smoking had been controlled for.

**Environmental Factors**

Although household exposure to ETS is a significant asthma risk factor among children,<sup>3</sup> we did not find that such exposure was significant among adults in our multivariate analyses of the 1998 NHIS data. Among adults, personal cigarette smoking is a stronger risk factor for asthma than smoking by others.

A survey conducted in Brooklyn showed that asthma prevalence was twice as high among Puerto Ricans as among Dominicans living in the same buildings.<sup>14</sup> The authors concluded that environmental factors alone could not explain the difference. Although that survey did not include questions on cigarette smoking, different smoking levels could have accounted for the differences in asthma prevalence between these 2 ethnic groups.

Because measurements of environmental allergens such as cockroaches, dust mites, pets, dampness and mold, and use of gas stoves in cooking and heating were not available in the present study,<sup>3</sup> we were not able to assess their effects. Indirect measures of exposure to allergens, such as living in an apartment or a home built before 1950 or living in a central city location, were not significant in our study. In previous studies, the effects of these environmental factors on asthma have not been consistent or conclusive.<sup>19</sup>

**Health Care Issues**

Previous researchers hypothesized that the high asthma prevalence found among Puerto Ricans compared with Mexican Americans was due to the better access to medical diagnosis available to Puerto Ricans.<sup>1,14</sup> Recent results from the Genetics of Asthma in Latino Americans Study<sup>15</sup> showed that even after stratifying on access to care so that both groups had the same access to medical diagnosis and treatment, Puerto Ricans had weaker lung function, more severe asthma, and less favorable responses to asthma medications than did Mexican Americans. The researchers also found indications of a genetic basis for the differences between the 2 groups.<sup>34</sup> In our study, health insurance coverage, an indication of access to health care,

TABLE 4—Continued

Body mass index, kg/m <sup>2</sup>		<.001
≥ 30 (obese)	1.81 (1.63, 2.02)	
25–29.9 (overweight)	1.21 (1.09, 1.35)	
18.5–24.9 (normal weight) <sup>a</sup>	1.00	
< 18.5 (underweight)	1.13 (0.86, 1.50)	
Unknown	1.28 (1.02, 1.61)	
<b>Health care variables</b>		
Health insurance coverage		.125
Not covered	1.11 (0.97, 1.26)	
Covered <sup>a</sup>	1.00	
Most recent doctor visit		<.001
≤ 6 months ago	3.23 (2.73, 3.83)	
> 6 months ago to 1 year	1.56 (1.26, 1.93)	
> 1 year ago or never <sup>a</sup>	1.00	
<b>Geographic variables</b>		
Census region of residence		<.001
West	1.34 (1.17, 1.53)	
South	0.95 (0.83, 1.09)	
Midwest	0.93 (0.80, 1.07)	
Northeast <sup>a</sup>	1.00	
Area of residence		.001
MSA, central city	1.16 (1.03, 1.32)	
MSA, not central city	0.97 (0.86, 1.08)	
Non-MSA <sup>a</sup>	1.00	

Note. MSA = metropolitan statistical area.

<sup>a</sup>Reference category. For ordinal variables, the reference category was the highest or lowest category large enough to provide a stable comparison. For nominal variables, the reference category was selected on the basis of literature review and our expertise.

was not significantly associated with either measure of asthma.

### Limitations

Because our study was derived from a general health survey rather than a survey designed to investigate risk factors for asthma, we did not assess many of the environmental variables found to be associated with asthma. Our study involved a large, nationally representative sample and the collection of data on fewer risk factors than can be collected from a smaller, regional sample, but our results can be generalized to the entire population of the United States. Integrating insights from both kinds of studies is necessary to provide a better understanding of the distribution of asthma in the US population.

Because we used cross-sectional data, our results could not show cause, nor could they distinguish between factors that increase the risk of developing asthma, those

that exacerbate symptoms, and those that precipitate an asthma attack. However, the results of 2 prospective studies of obesity and asthma were the same as those obtained in our cross-sectional analysis.<sup>16,17</sup>

Another limitation of this study is that genetic factors were not included. Although a gene has been identified that is potentially related to asthma among non-Hispanic Whites,<sup>35</sup> that result has not been replicated in Hispanic populations,<sup>36</sup> suggesting that different genes may affect susceptibility to asthma in different racial/ethnic groups.<sup>37</sup> One hypothesis potentially relevant to Puerto Ricans is that asthma is triggered by a gene–environment interaction in which the genes that led to enhanced IgE production were selected for in populations living in tropical areas with endemic helminth infections. When such populations migrate to urban areas and are exposed to urban allergens, it is postulated that the same

genes can lead to asthmatic responses.<sup>38</sup> Further study of gene–environment interactions with asthma is needed among Puerto Ricans.<sup>24,39</sup>

### Conclusions

Three main conclusions can be drawn from the results of this study. First, “Hispanics” is too general a term to use in studying asthma in different population groups. If possible, a Puerto Rican subgroup and at least one Mexican subgroup should be delineated. If a particular study cannot include a sufficient number of respondents from both groups, the larger group should be described and analyzed, and the other group should be excluded from the analysis. Second, when a study includes geographic variables, respondents should be selected from more than 1 region. Third, even if genetic material cannot be collected, surveys should include questions on parents’ asthma diagnoses. Future studies need to examine as many demographic, behavioral, environmental, and genetic factors as possible to better our understanding of asthma and to develop more effective prevention and treatment strategies. ■

### About the Authors

Deborah Rose is with the Division of Health Interview Statistics, National Center for Health Statistics, Centers for Disease Control and Prevention, Hyattsville, Md. At the time of this study, David M. Mannino was with the Air Pollution and Respiratory Health Branch, National Center for Environmental Health, Centers for Disease Control and Prevention, Atlanta, Ga. Brian P. Leaderer is with the Department of Epidemiology and Public Health, Yale School of Medicine, New Haven, Conn.

Requests for reprints should be sent to Deborah Rose, PhD, Data Analysis and Quality Assurance Branch, Division of Health Interview Statistics, National Center for Health Statistics, 3311 Toledo Rd, Room 2320, Hyattsville, MD 20782 (e-mail: drose@cdc.gov).

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### Contributors

D. Rose originated the study on the basis of a suggestion by B. P. Leaderer. D. Rose carried out the data analysis and wrote the initial drafts, with advice from D. M. Mannino and B. P. Leaderer. All of the authors helped to refine the analysis, interpret the findings, and revise the article.

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### Human Participant Protection

The survey and data collection operation of the National Health Interview Survey undergoes extensive review by the research ethics review board of the National Center for Health Statistics each year and requires participants' written informed consent. All of the data used in this study were approved by this review board.

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