Neighborhood poverty, urban residence, race/ethnicity, and asthma: Rethinking the inner-city asthma epidemic

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Background: Although it is thought that inner-city areas have a high burden of asthma, the prevalence of asthma in inner cities across the United States is not known.
Objective: We sought to estimate the prevalence of current asthma in US children living in inner-city and non–inner-city areas and to examine whether urban residence, poverty, or race/ethnicity are the main drivers of asthma disparities.
Methods: The National Health Interview Survey 2009-2011 was linked by census tract to data from the US Census and the National Center for Health Statistics. Multivariate logistic regression models adjusted for sex; age; race/ethnicity; residence in an urban, suburban, medium metro, or small metro/rural area; poverty; and birth outside the United States, with current asthma and asthma morbidity as outcome variables. Inner-city areas were defined as urban areas with 20% or more of households at below the poverty line.
Results: We included 23,065 children living in 5,853 census tracts. The prevalence of current asthma was 12.9% in inner-city and 10.6% in non–inner-city areas, but this difference was not significant after adjusting for race/ethnicity, region, age, and sex. In fully adjusted models black race, Puerto Rican ethnicity, and lower household income but not residence in poor or urban areas were independent risk factors for current asthma. Household poverty increased the risk of asthma among non-Hispanics and Puerto Ricans but not among other Hispanics. Associations with asthma morbidity were very similar to those with prevalent asthma.
Conclusions: Although the prevalence of asthma is high in some inner-city areas, this is largely explained by demographic factors and not by living in an urban neighborhood. (J Allergy Clin Immunol 2014;■■■:■■■-■■■.)

Key words: *Inner-city asthma, childhood asthma, urban/rural, neighborhood, race/ethnicity*

The idea that certain features of life in poor urban areas promote asthma dates back to more than a half century ago, when researchers began to describe an "inner-city asthma epidemic" of high asthma prevalence and morbidity in poor areas of large cities.[1-8] Research focusing on the inner city, which was typically defined as census tracts in large metro center areas with at least 20% of households at below the poverty line,[9] has led to significant advances in our understanding of what causes asthma and how to treat it,[10] but the prevalence of asthma in inner-city areas across the United States is not known nor is it known how it compares with prevalence in other types of communities. Studies of asthma prevalence in the inner city have generally focused on individual urban communities and have not separated demographic features of inner-city areas from their metropolitan status.[5,11-19] Nationally representative studies have also had several limitations, including the fact that much of the work on the relative contribution of metropolitan status to asthma disparities overall was done decades ago, used measures of metropolitan status that are not consistent with National Institutes of Health definitions of the inner city, and rarely looked at the independent contributions of poverty, metropolitan status, and race/ethnicity.[3,6,20] Despite our significant and ongoing national commitment to combating inner-city asthma, we do not actually know the prevalence of asthma in inner cities across the United States, whether it is in fact greater than that found in other areas, and, if there are differences, whether race/ethnicity, poverty, or residence in an urban area explain them.

Thus our primary objectives were to (1) estimate childhood asthma prevalence for inner-city and non–inner-city areas in the United States and (2) disentangle the effects of urban residence, neighborhood-level poverty, race/ethnicity, and household poverty on asthma prevalence. Understanding whether asthma disparities seen in various geographic areas are primarily a result of environmental exposures concentrated in the inner city or are instead related to sociodemographic features of the inhabitants of these neighborhoods is key to advancing an efficient and effective national research and public health agenda.

METHODS

Data were drawn from the National Health Interview Survey (NHIS) 2009-2011. The NHIS is a survey conducted annually by the National Center for

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Abbreviations used
CDC: Centers for Disease Control and Prevention
NCHS: National Center for Health Statistics
NHIS: National Health Interview Survey
OR: Odds ratio

Health Statistics (NCHS), which is part of the Centers for Disease Control and Prevention (CDC). It has a multistate probability design that covers all 50 states and the District of Columbia and is intended to be representative of the civilian noninstitutionalized population living in the United States. Black, Asian, and Hispanic populations are oversampled to increase precision of estimates in certain subgroups. Data collection is done in person using a computer-assisted personal interviewing mode. The overall response rate for the child section of these surveys ranged from 71% to 75%.[21-23] Because asthma is not reliably diagnosed in young children, the sample population was limited to children aged 6 to 17 years.

To evaluate the effect of geographic variables on asthma outcomes, we linked participants' census tracts, as classified by the 2000 Census, to 2 additional data sets: the 2006 NCHS Urban-Rural Classification Scheme for Counties and the 2000 US Census. The 2006 NCHS Urban-Rural Classification scheme divides counties into 6 categories based on population density and other measures of urbanization: (1) large metro, central; (2) large metro, fringe; (3) medium metro; (4) small metro; (5) micropolitan; and (6) noncore. Generally, "large metro, central" is considered the urban core, whereas "large metro, fringe" is thought to be equivalent to "suburban."[24] Because there were relatively few people residing in small metro, micropolitan, and noncore areas, these categories were combined and classified as small metro/rural areas. The 2000 Census provided the percentage of households living at below the federally defined poverty level in each census tract. This was generally treated as a continuous variable in our analyses, although in some analyses we defined inner-city neighborhoods as census tracts located in large metro central areas with 20% or more of households at below the poverty line.[9] *Household income* was defined as household income divided by the federally defined poverty level.

Ever asthma was defined by a yes answer to the following question: "Has a doctor or other health professional EVER told you that [name] had asthma?" Other questions that defined asthma were as follows: "Does [name] still have asthma?," which was used for current asthma. "During the past 12 months, has [name] had an episode of asthma or an asthma attack?," which was used for an asthma episode. "During the past 12 months, did [name] have to visit an emergency room or urgent care center because of [his/her] asthma?," which was for an asthma emergency department visit.

Race/ethnicity was by self-report and recoded in the NHIS data in the following categories: Hispanic, non-Hispanic white (called "white" here), non-Hispanic black (called "black" here), non-Hispanic Asian (called "Asian" here), and all other race/ethnicities, a group comprising less than 1% of the total population. Because it has been previously reported that Puerto Rican Hispanics have different asthma risk than other Hispanics,[25] we created a separate race/ethnicity category for those of Puerto Rican heritage. Hereafter, "Hispanic" refers to non-Puerto Rican Hispanics.

Although multilevel modeling is often used in analyses of the association between neighborhood factors and disease, multilevel modeling typically requires at least 25 subjects per group (in this case census tract),[26] and in this analysis there were an average of only 4 subjects per census tract. Thus, for this analysis, standard survey methods were used with sample weights and strata provided in the survey. This accounts for the complex survey design, correctly adjusts the variances for clustering within a sampling unit, and does not require a minimum number of subjects per group. For analyses of individual-level income, the CDC provides multiply imputed data for subjects missing income data. These data are generated by the CDC by using sequential regression multivariate imputation implemented with the module IMPUTE with IVEware (www.isr.umich.edu/src/smp/ive)[27] and were analyzed with the MI ESTIMATE commands in Stata, which accounts for the imputation uncertainty using the methods of Rubin.[28] Three logistic regression models for prediction of current asthma, asthma episodes, and emergency department visits in the past year were generated: crude bivariate analyses; multivariate models adjusted for age, sex, race/ethnicity, region of residence, neighborhood-level poverty, and urban/rural status; and multivariate models additionally adjusted for household income. To determine whether race/ethnicity or metropolitan residence modified the relationship between poverty and asthma, we also investigated interactions between these factors and constructed stratified models. Model diagnostics included the Pearson goodness-of-fit test, visual examination of the data, and sensitivity analyses excluding very large values. Individual- and neighborhood-level poverty were examined for collinearity, and because the collinearity was not strong (variance inflation factor of 1.2), both variables were included in some models. Because we identified differences in the relationship between current asthma and both neighborhood- and individual-level poverty between Hispanics and non-Hispanics, we stratified these analyses into (1) Hispanics and (2) all others, including Puerto Ricans. Our analyses confirmed that children of Puerto Rican heritage were more similar to non-Hispanic populations than Hispanics in the relationship between asthma and poverty (data not shown), supporting this method of stratification. Sensitivity analyses of the main model were done, including the following variables: (1) whether the child had a well-child visit in the past year and (2) whether the child had at any point been uninsured in the past year. A significance level of .05 was used. All analyses were done with Stata 13/SE software (StataCorp, College Station, Tex). Because census tract information is not available in the public NHIS data set, these analyses were conducted at the Research Data Center with approval from the NCHS Research Ethics Review Board. Data collection for the NHIS was approved by the NCHS Research Ethics Review Board.

RESULTS

Population characteristics

Twenty-three thousand sixty-five subjects aged 6 to 17 years living in 5,853 different census tracts were included in this analysis. Because the sample was derived from a population-based survey and was weighted to reflect the noninstitutionalized US population, the demographics of the analytic population matched those of children aged 6 to 17 years in the United States as a whole (Table I). On average, subjects resided in census tracts in which 12% of households lived at below the poverty line. Twenty-eight percent resided in urban census tracts, 16% resided in poor tracts (defined as ≥20% living at below the poverty line), and 7% resided in poor urban tracts (the inner city, Table I). The lifetime asthma prevalence was 16.3%, the current asthma prevalence was 10.7%, 5.9% reported an asthma episode, and 1.6% reported visiting the emergency department for asthma in the prior year.

Prevalence of asthma in urban poor (inner-city) and other poor areas

The overall prevalence of current asthma in inner-city neighborhoods in the United States was 12.9% (95% CI, 11.1% to 14.9%) compared with 10.6% (95% CI, 10.0% to 11.2%) in non–inner-city areas ($P = .01$), but this difference was no longer significant after adjusting for race/ethnicity, region, sex, and age (odds ratio [OR], 1.01; 95% CI, 0.84-1.21; $P = .90$). Approximately 8% of asthmatic children are estimated to live in inner-city areas compared with 7% of children overall (see Table E1 in this article's Online Repository at www.jacionline.org). The prevalence of asthma in inner-city neighborhoods was not constant throughout the United States and ranged from 7.9% (95% CI, 5.9% to 10.5%) in the West to 17.3% (95% CI, 13.2% to 22.4%) in the Northeast (Fig 1). In addition, poor

TABLE I. Demographic characteristics

Characteristic	No.	Overall	Poor* urban (n = 2,411)	Nonpoor urban (n = 5,383)	Poor nonurban (n = 2,337)	Nonpoor nonurban (n = 12,934)
		% (95% CI)				
Race/ethnicity						
White	10,425	57.6 (56.5-58.7)	7.2 (5.0-10.3)	45.3 (42.3-47.8)	32.3 (28.3-36.6)	71.3 (70.0-72.6)
Black	4,067	15.2 (14.5-16.0)	36.7 (32.9-40.7)	16.7 (15.0-18.6)	28.5 (24.9-32.3)	10.4 (9.6-11.2)
Hispanic (non–Puerto Rican)	6,301	19.5 (18.7-20.4)	48 (44.2-52.0)	27 (25.0-29.2)	31 (27.3-35.1)	12.1 (11.1-13.2)
Puerto Rican	600	2.1 (1.8-2.3)	3.9 (2.9-5.2)	2.2 (1.7-2.8)	3.6 (2.6-4.9)	1.6 (1.3-1.9)
Asian	1,464	4.5 (4.1-4.9)	3.7 (2.6-5.3)	8.4 (7.4-9.6)	1.6 (1.1-2.4)	3.7 (3.3-4.2)
Region						
Northeast	3,475	16.5 (15.6-17.4)	24.2 (20.7-28.1)	11.2 (9.5-13.1)	9.5 (7.1-12.5)	18.5 (17.2-19.8)
Midwest	4,564	24.2 (23.0-25.3)	13.8 (11.2-16.7)	18.5 (15.8-21.5)	13.2 (9.7-17.6)	28.9 (27.2-30.5)
South	7,871	35.3 (34.0-36.6)	24.6 (20.7-29.0)	30.6 (27.6-33.7)	51.3 (46.1-56.5)	35.7 (34.0-37.5)
West	6,047	24.0 (22.8-25.2)	37.5 (32.7-42.5)	39.8 (36.8-42.8)	26.1 (22.0-30.7)	17.0 (15.4-18.7)
Born in United States						
Yes	21,320	94.3 (93.9-94.7)	89.1 (87.4-90.7)	92 (91.0-92.9)	92.9 (90.8-94.5)	95.9 (95.4-96.3)
No	1,735	5.7 (5.3-6.1)	10.9 (9.4-12.6)	8 (7.2-9.0)	7.1 (5.5-9.2)	4.1 (3.7-4.6)
Asthma prevalence						
Asthma, lifetime	3,933	16.3 (15.7-17.0)	18.7 (16.5-21.2)	15.3 (14.0-16.6)	19.2 (17.1-21.5)	16 (15.3-16.8)
Asthma, current	2,574	10.7 (10.2-11.3)	12.9 (11.1-14.9)	10 (9.0-11.2)	12.4 (10.8-14.2)	10.5 (9.9-11.2)
Asthma episode, past 12 mo	1,378	5.9 (5.5-6.3)	6.5 (5.5-7.7)	5.6 (4.8-6.5)	6.1 (4.9-7.6)	5.9 (5.4-6.4)
ED visit for asthma, past 12 mo	408	1.6 (1.4-1.8)	3.0 (2.2-4.0)	1.8 (1.3-2.5)	2.3 (1.6-3.1)	1.3 (1.4-1.8)

ED, Emergency department.
**Poor* was defined as 20% or more of households living below the poverty line.

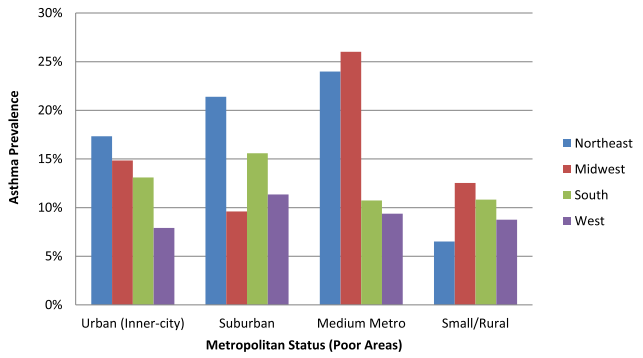

FIG 1. Asthma prevalence according to metropolitan status and region among children living in poor areas (defined as neighborhoods with ≥20% of households below the poverty line).

non–inner-city areas in some regions had prevalence rates exceeding those in inner-city areas (Fig 1 and see Table E2 in this article's Online Repository at www.jacionline.org). Although in crude stratified analyses inner-city areas in the Northeast had higher prevalence rates than non–inner-city areas, in stratified models adjusted for age, sex, place of birth, and race/ethnicity, the prevalence of asthma in inner-city neighborhoods was not significantly higher than in non–inner-city areas in any region of the United States (data not shown). As shown below, differences in asthma prevalence were driven by racial/ethnic and socioeconomic factors and not urban/rural status.

Associations with current asthma prevalence

Race/ethnicity. In unadjusted models current asthma prevalence was significantly higher among blacks (17.1%; 95% CI, 15.6% to 18.8%) and Puerto Ricans (19.8%; 95% CI, 16.6% to 23.5%) than among whites (9.6%; 95% CI, 8.9% to 10.3%), Hispanics (8.8%; 95% CI, 7.8% to 10.0%), and Asians (8.1%; 95% CI, 6.5% to 10.0%). Black race and Puerto Rican ethnicity remained strong and independent predictors of current asthma, even when neighborhood-level poverty, urban/rural status, region, sex, age, and birth in the United States were included in the model and, additionally, in analyses that further adjusted for household poverty (Table II and see Table E3 in this article's Online Repository at www.jacionline.org). Birth outside the United States was a strong and independent protective factor for asthma (Table II).

Neighborhood poverty. A 10 percentage point increase in the number of households living below the poverty line (neighborhood-level poverty) was associated with a 10% increase in the odds of prevalent asthma in crude analyses (OR, 1.10; 95% CI, 1.05-1.14; $P < .001$), although this was no longer significant in adjusted analyses (OR, 1.04; 95% CI, 0.99-1.10; $P = .09$). Race/ethnicity was found to significantly modify the relationship between neighborhood-level poverty and prevalent asthma ($P = .004$ for the interaction between Hispanic ethnicity and neighborhood-level poverty), with neighborhood-level poverty as a significant risk factor among non-Hispanics and Puerto Ricans in adjusted analyses but protective among Hispanics (Table II). Sensitivity analyses, including whether the child received well-child care in the past year or was uninsured at any point, did not materially change the results of these analyses or those of residence in an urban neighborhood (data not shown).

Individual-level household poverty. In unadjusted analyses a 1-unit decrease in the household income to poverty ratio was associated with a 7% increase in the odds of prevalent asthma (95% CI, 1.05-1.10; $P < .001$), with similar results in the model that adjusted for race/ethnicity, urban/rural status, region, age,

TABLE II. Predictors of current asthma

	Crude			Adjusted*		
	OR	95% CI	*P* value	OR	95% CI	*P* value
Overall						
Race/ethnicity						
White			Reference			
Black	1.95	1.70-2.23	<.001	1.87	1.59-2.19	<.001
Hispanic	0.91	0.78-1.07	.26	1.02	0.85-1.23	.81
Puerto Rican	2.33	1.83-2.95	<.001	2.38	1.82-3.11	<.001
Asian	0.83	0.65-1.06	.13	1.01	0.79-1.30	.93
Urbanization						
Urban			Reference			
Suburban	1.03	0.90-1.19	.66	1.14	0.97-1.33	.11
Medium metro	0.97	0.83-1.14	.72	1.05	0.88-1.24	.60
Small metro/rural	1.00	0.85-1.16	.95	1.10	0.92-1.31	.30
Region						
Northeast			Reference			
Midwest	0.93	0.79-1.11	.43	0.98	0.82-1.16	.81
South	0.87	0.75-1.01	.06	0.85	0.73-0.99	.40
West	0.77	0.66-0.91	.002	0.90	0.76-1.07	.25
Birth outside the United States	0.32	0.23-0.45	<.001	0.33	0.24-0.47	<.001
Household poverty†	1.07	1.05-1.10	<.001			
Neighborhood poverty‡	1.10	1.05-1.14	<.001	1.04	0.99-1.10	.09
Hispanics						
Urbanization						
Urban			Reference			
Suburban	1.21	0.88-1.66	.24	1.13	0.81-1.57	.48
Medium metro	1.21	0.85-1.72	.28	1.25	0.88-1.78	.22
Small metro/rural	1.08	0.71-1.64	.72	1.11	0.72-1.70	.64
Household poverty†	0.95	0.89-1.01	.09			
Neighborhood poverty‡	0.90	0.83-0.98	.02	0.90	0.83-0.98	.02
Non-Hispanics and Puerto Ricans						
Urbanization						
Urban			Reference			
Suburban	0.93	0.79-1.09	.37	1.13	0.95-1.36	.17
Medium metro	0.88	0.73-1.05	.15	1.01	0.83-1.22	.93
Small metro/rural	0.91	0.76-1.08	.28	1.07	0.88-1.30	.48
Household poverty†	1.10	1.07-1.14	<.001			
Neighborhood poverty‡	1.20	1.14-1.26	<.001	1.09	1.02-1.16	.008

*Adjusted for age, sex, race/ethnicity, region, neighborhood-level poverty, urban/rural status, and birth outside the United States.
†One-unit increase in ratio of household income to the poverty line.
‡Ten percentage point increase in households living below the poverty line.

sex, and birth in the United States (OR, 1.06; 95% CI, 1.03-1.09; $P < .001$). As was the case for neighborhood-level poverty, Hispanic ethnicity significantly modified the relationship between household poverty and prevalent asthma ($P = .002$), and household poverty was a risk factor for asthma among non-Hispanics and Puerto Ricans (OR, 1.07; 95% CI, 1.03-1.10; $P < .001$) but not Hispanics (OR, 1.00; 95% CI, 0.94-1.07; $P = .94$) in adjusted analyses.

When both neighborhood- and individual-level poverty were included in the model, neighborhood-level poverty was no longer a significant predictor of prevalent asthma in the overall or stratified models, but individual-level poverty remained an independent predictor overall and among non-Hispanics and Puerto Ricans (see Table E3 in this article's Online Repository at www.jacionline.org).

Residence in an urban neighborhood. There were no differences in asthma prevalence in suburban, small-town, and rural neighborhoods compared with urban neighborhoods in either crude or adjusted analyses overall or in analyses stratified by Hispanic ethnicity (Table II), and residence in an urban area did not increase the association between race/ethnicity and asthma prevalence (data not shown). Moreover, living in an urban environment did not increase the association between neighborhood-level poverty and asthma prevalence ($P = .62$).

Asthma morbidity

Black race, Puerto Rican ethnicity, and lower household income were strong independent risk factors for asthma exacerbation and emergency department visits for asthma (Tables III and IV and see Table E3). Neighborhood poverty and urban/rural status were not risk factors in adjusted analyses, with the exception of a protective effect of residence in small metro/rural areas compared with urban areas for emergency department visits in fully adjusted models of the overall population and among non-Hispanics and Puerto Ricans (see Table E3).

DISCUSSION

Although it has long been thought that the prevalence of asthma is high among children living in poor urban neighborhoods in the

TABLE III. Predictors of asthma episode

	Crude			Adjusted*		
	OR	95% CI	*P* value	OR	95% CI	*P* value
Overall						
Race/ethnicity						
White			Reference			
Black	1.71	1.45-2.01	<.001	1.64	1.36-1.97	<.001
Hispanic	0.78	0.65-0.95	.01	0.84	0.68-1.05	.13
Puerto Rican	2.32	1.67-3.22	<.001	2.40	1.66-3.47	<.001
Asian	0.74	0.51-1.08	.11	0.93	0.63-1.36	.70
Urbanization						
Urban			Reference			
Suburban	1.02	0.85-1.22	.83	1.09	0.88-1.34	.43
Medium metro	1.02	0.84-1.26	.78	1.09	0.87-1.35	.46
Small metro/rural	0.99	0.82-1.19	.89	1.03	0.83-1.29	.77
Region						
Northeast			Reference			
Midwest	1.01	0.80-1.28	.93	1.07	0.84-1.37	.58
South	0.99	0.80-1.21	.89	1.01	0.82-1.24	.94
West	0.82	0.66-1.02	.07	1.00	0.79-1.26	.98
Birth outside the United States	0.31	0.20-0.47	<.001	0.34	0.22-0.53	<.001
Household poverty†	1.06	1.02-1.10	.003			
Neighborhood poverty‡	1.06	1.00-1.11	.04	1.02	0.96-1.09	.50
Hispanics						
Urbanization						
Urban			Reference			
Suburban	0.95	0.63-1.45	.82	0.89	0.57-1.39	.61
Medium metro	1.26	0.87-1.84	.21	1.08	0.93-1.95	.12
Small metro/rural	0.88	0.51-1.54	.66	0.87	0.50-1.52	.63
Household poverty†	0.98	0.92-1.03	.4			
Neighborhood poverty‡	0.9	0.79-1.02	.09	0.91	0.80-1.03	.13
Non-Hispanics and Puerto Ricans						
Urbanization						
Urban			Reference			
Suburban	0.94	0.76-1.15	.53	1.12	0.88-1.42	.36
Medium metro	0.93	0.74-1.17	.53	1.05	0.81-1.36	.70
Small metro/rural	0.91	0.74-1.13	.39	1.05	0.82-1.35	.70
Household poverty†	1.09	1.05-1.14	<.001			
Neighborhood poverty‡	1.15	1.08-1.23	<.001	1.05	0.97-1.13	.20

*Adjusted for age, sex, race/ethnicity, region, neighborhood-level poverty, urban/rural status, and birth outside the United States.
†One-unit increase in ratio of household income to the poverty line.
‡Ten percentage point increase in households living below the poverty line.

United States, the prevalence of asthma in these neighborhoods throughout the United States has, surprisingly, not been described. Moreover, the relative contribution of race/ethnicity and household poverty versus other contextual neighborhood-level factors to asthma disparities related to the inner city remains unclear. Here we show that although some inner-city areas have high rates of asthma, particularly in the Midwest and Northeast, other nonurban poor areas have equal or higher asthma prevalence. Overall, black race, Puerto Rican ethnicity, and poverty rather than residence in an urban area *per se* are the major risk factors for prevalent asthma. These findings suggest that the concept of inner-city asthma might need to be refined.

Original reports heralding the phenomenon of inner-city asthma were based on findings of very high asthma morbidity and mortality in several cities, including Baltimore, Chicago, and New York City, and further research documented that poor neighborhoods in these cities were particularly affected.[1,5,7,8,19] These urban areas were also disproportionately home to ethnic minorities, particularly non-Hispanic blacks and Puerto Ricans, who were known to be at risk for asthma.[4] However, early research found conflicting results about whether racial/ethnic disparities were independent of socioeconomic factors.[3,6,20] Since that time, black race and Puerto Rican ethnicity have become clear risk factors for asthma, although how much this is due to environmental exposures, including urban exposures, or to underlying susceptibility remains unknown. Race is a complex concept that is informed by genetic, cultural, and historical factors, and thus it can be hard to parse genetic from environmental risk factors. Degree of African ancestry has been associated with asthma,[29-31] suggesting a genetic explanation, although it can be difficult to fully account for confounding by socioeconomic status, even in genetic analyses,[32,33] particularly because disparities in wealth, educational opportunities, family structure, and employment by race/ethnicity are even higher than what is represented by income[34] and can correlate with ancestry. Here, in a very large and nationally representative data set, we found that black race and Puerto Rican ethnicity were strong risk factors for prevalent asthma and asthma morbidity independent of income, neighborhood-level poverty, and residence in an urban setting, but we cannot exclude residual confounding as an explanation for the association between race/ethnicity and asthma.

TABLE IV. Predictors of asthma ED visit

	Crude			Adjusted*		
	OR	95% CI	*P* value	OR	95% CI	*P* value
Overall						
Race/ethnicity						
White			Reference			
Black	4.07	3.03-5.46	<.001	3.45	2.45-4.87	<.001
Hispanic	1.41	0.98-2.01	.06	1.24	0.81-1.90	.31
Puerto Rican	5.41	3.23-9.04	<.001	4.48	2.64-7.58	<.001
Asian	0.89	0.46-1.73	.74	0.96	0.48-1.92	.90
Urbanization						
Urban			Reference			
Suburban	0.61	0.41-0.89	.01	0.75	0.47-1.18	.21
Medium metro	0.88	0.60-1.29	.52	1.06	0.70-1.58	.79
Small metro/rural	0.51	0.35-0.74	<.001	0.66	0.43-1.02	.06
Region						
Northeast			Reference			
Midwest	0.74	0.49-1.12	.16	0.89	0.60-1.32	.56
South	0.82	0.58-1.16	.25	0.82	0.58-1.16	.25
West	0.66	0.43-1.00	.049	0.80	0.51-1.24	.31
Birth outside the United States	0.36	0.19-0.66	.001	0.38	0.19-0.75	.005
Household poverty†	1.22	1.13-1.31	<.001			
Neighborhood poverty‡	1.24	1.14-1.36	<.001	1.04	0.93-1.16	.49
Hispanics						
Urbanization						
Urban			Reference			
Suburban	0.67	0.30-1.48	.32	0.70	0.29-1.68	.42
Medium metro	1.08	0.52-2.21	.84	1.22	0.61-2.46	.57
Small metro/rural	0.65	0.20-2.08	.46	0.79	0.24-2.56	.69
Household poverty†	1.06	0.90-1.26	.49			
Neighborhood poverty‡	1.04	0.83-1.32	.71	1.07	0.86-1.33	.50
Non-Hispanics and Puerto Ricans						
Urbanization						
Urban			Reference			
Suburban	0.55	0.35-0.86	.008	0.75	0.44-1.26	.28
Medium metro	0.80	0.52-1.23	.31	1.02	0.64-1.63	.93
Small metro/rural	0.45	0.31-0.67	<.001	0.65	0.41-1.03	.07
Household poverty†	1.27	1.16-1.38	<.001			
Neighborhood poverty‡	1.34	1.22-1.48	<.001	1.03	0.90-1.18	.65

ED, Emergency department.
*Adjusted for age, sex, race/ethnicity, region, neighborhood-level poverty, urban/rural status, and birth outside the United States.
†One-unit increase in ratio of household income to the poverty line.
‡Ten percentage point increase in households living below the poverty line.

Residence in urban areas, a potential risk factor for asthma hypothesized to be mediated by exposure to indoor and outdoor pollution, pest allergens, and violence and other stressful life events,[20,35] was not found to be a significant risk factor for prevalent asthma or asthma morbidity in this US population–based analysis. The lack of a relationship between urban residence and asthma prevalence, even in crude analyses, might reflect shifting demographics since the inner-city asthma epidemic was first described. Although urban areas have historically tended to be poor, in recent years, the fastest growth in high-poverty areas has occurred in suburban and smaller metropolitan areas, with the slowest growth in the largest cities, as shown by the US Census' Decennial and American Communities Surveys.[36,37] The suburbanization of poverty means that despite continued high rates of concentrated poverty in cities, there are now more poor people living in suburban than urban communities.[36,37] The ethnic composition of poor and urban areas has also shifted, with a so-called "reverse migration" of black populations from Northern cities to the South[38] and an influx of Hispanic populations to urban areas,[39] where they are now the most common ethnic group. These demographic changes challenge the use of "inner city" as interchangeable with black race and mean that focusing on the inner city might not fully capture the population most at risk for asthma. In this survey we estimate that inner-city areas now house only 8% of all children with current asthma compared with the 46% living in suburban or wealthier urban areas, which follows a similar distribution to children as a whole. The environmental factors contributing to asthma in non–inner-city areas, especially poor suburban and medium metro areas, have been relatively less studied than those in the inner city.

In contrast to residence in an urban area, neighborhood- and individual-level poverty were both associated with prevalent asthma, although neighborhood-level poverty was not independent of individual-level household poverty. Poverty can lead to increased risk of asthma through many pathways because known risk factors for asthma are more common in poorer households;

including smoking; shorter duration of breast-feeding; prematurity; higher levels of indoor allergens, such as cockroach and mouse allergens; exposure to outdoor pollution, such as diesel particles; poorer diet; and psychological stress.[40] Poverty (both neighborhood and household) was not a risk factor for non-Puerto Rican Hispanics and was in fact protective, a finding that has been reported in a smaller study in California.[41] Many of the risk factors for asthma that are found in poorer households in general might actually be less common among poorer, less acculturated Hispanic households.[42] Increased acculturation has been linked to higher prevalence of asthma risk factors, including shorter duration of breast-feeding,[43] smoking,[44] prematurity,[45,46] and poor diet,[47] and has been shown to be a risk factor for asthma among Mexican Hispanics.[48,49] Although we adjusted for the subject child's birth outside the United States, our analyses did not adjust for the immigration status of the child's parent, and thus acculturation is a potential explanation for the inverse relationship between poverty and asthma we found among Hispanics, although differences in diagnosis and gene-environment interactions might also play a role.

There are several important caveats to our findings. First, because the research questions addressed in this study could only be answered with a very large study population, the data, by necessity, were obtained by means of self-report. Differences in the likelihood of diagnosis of asthma by race, socioeconomic status, or geography could potentially bias our results. However, assessment of asthma by the NHIS questions is a standard and well-accepted approach to identifying asthma,[50] and self-report of race/ethnicity is considered the gold standard.

Second, there is potential for misclassification of neighborhood characteristics because subjects were surveyed in 2009-2010 but were assigned to year 2000 census tracts in the NHIS survey. These tracts were linked to year 2000 census data for poverty and year 2005 urban/rural definitions. We expect that any changes in distribution of neighborhood-level poverty over the past decade, leading to misclassification of neighborhood-level poverty, are likely to lead to a bias toward the null in our analyses of the relationship between neighborhood-level poverty and asthma, whereas urban/rural status is unlikely to change substantially over 4 to 6 years.

Finally, with regard to asthma morbidity, the outcome measures were fairly crude, and there was less power than for analyses of asthma prevalence overall. Therefore we cannot exclude the possibility that residence in an urban area and poverty might have a stronger role in asthma morbidity than prevalent asthma. In addition, access to care, including emergency care, might explain some of our results, particularly the finding that those living in a rural area were less likely to have emergency department visits for asthma. More research is needed to understand how urban/rural status might affect other measures of asthma morbidity and asthma severity.

These limitations, however, are countered by the study's strengths, which are that it is representative of the US population and of sufficient size to disentangle the effects of race/ethnicity, neighborhood-level poverty, and urban residence on asthma.

In conclusion, our work suggests that the concept of inner-city asthma might need to be revised. Focusing only on urban areas could miss communities that are also at high risk of asthma, particularly those with high concentrations of black, Puerto Rican, and poor children. This work highlights the need for a broad view of asthma disparities to develop the research and public health measures that are most likely to be effective in preventing and managing asthma.

Key messages

- **Although the prevalence of asthma is high in some US inner cities, it is equally high in some poor nonurban areas.**
- **Taking the United States as a whole, living in an urban neighborhood is not associated with increased asthma prevalence.**

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