

Health Disparities Among Children with Asthma in the United States by Place of Residence



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What is already known about this topic? Children residing in poor-urban areas may have greater asthma morbidity. It is unclear whether this is due to individual characteristics such as race and ethnicity or place of residence.

What does this article add to our knowledge? The results show that poor-urban residence may be independently associated with asthma control and treatment even after controlling for individual characteristics such as race and ethnicity.

How does this study impact current management guidelines? In addition to individual characteristics that may influence asthma outcomes, place of residence may be an important factor to consider in determining the clinical management of asthma in children.

BACKGROUND: Children residing in poor-urban areas may have greater asthma morbidity. It is unclear whether this is due to individual characteristics such as race and ethnicity or place of residence.

OBJECTIVE: Assess indicators of control and treatment by residence.

METHODS: This was a cross-sectional analysis of children (aged 1-17 years) in the 2000-2014 Medical Expenditure Panel Survey (MEPS). Indicators of poor control included use of more than 3 canisters of short-acting beta agonist (SABA) in 3 months, asthma attack, and emergency department (ED) or inpatient (IP) visit during the year. Treatment measures included use of

controller medications and a ratio of controller-to-total prescriptions of 0.7 or more.

RESULTS: There were 15,052 children with asthma in the MEPS 2000-2014 data, reflecting 8.4 million children in 2014. After controlling for covariates, children with asthma residing in poor-urban areas had lower odds of using controller medications (odds ratio [OR] = 0.77), having a controller-to-total ratio of 0.7 or more (OR = 0.75), and reporting an asthma attack (OR = 0.75) and higher odds of having an ED/IP visit (OR = 1.3) compared with those living elsewhere. Black race and Hispanic ethnicity were associated with greater odds of excessive SABA use (OR = 2.11) and ED/IP visits (OR = 2.03) and lower odds of controller-to-total ratio of 0.07 or more (OR = 0.50). **CONCLUSIONS:** Poor-urban residence may be independently associated with asthma control and treatment even after controlling for individual characteristics such as race and ethnicity. Future research is needed to understand the sources of these geographic health disparities to more successfully target public health interventions. © 2019 American Academy of Allergy, Asthma & Immunology (J Allergy Clin Immunol Pract 2019;7:148-55)

Key words: Health disparities; Pediatric asthma; Poor-urban; Race; Ethnicity; Inner-city

BACKGROUND

Research has documented the high asthma prevalence among residents of poor-urban ("inner-city" in the past) areas since the 1960s.¹⁻³ This body of research has led to large-scale public health efforts to reduce the burden of asthma in poor-urban areas and has significantly advanced our understanding of asthma and its treatment. A recent study by Keet et al⁴ using the 2009-2011 National Health Interview Survey (NHIS) showed that although the prevalence of asthma is higher in poor-urban areas, it is largely due to race and ethnicity characteristics concentrated in

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Abbreviations used

AHRQ- Agency for Healthcare Research and Quality

ED- emergency department

FIPS- Federal Information Processing Standard

HC- Household Component

IP- inpatient

MEPS- Medical Expenditure Panel Survey

MSA- Metropolitan Statistical Area

NCC- number of chronic conditions excluding asthma

NCHS- National Center for Health Statistics

NHIS- National Health Interview Survey

OR- odds ratio

SABA- short-acting beta agonist

these geographic areas. After controlling for these characteristics, the prevalence of asthma was not significantly higher in poor-urban areas. These findings are highly relevant to public health efforts aimed at reducing the new onset of asthma cases, suggesting a refocus on the importance of individual characteristics such as race/ethnicity rather than geographical characteristics such as poor-urban areas.

Equally important is understanding the factors associated with asthma morbidity among children with current asthma in the United States. Asthma morbidity during childhood is paramount because persistent symptoms can increase the risk of exacerbations, which can lead to progressive loss of lung function that can last into adulthood.⁵ There is ample evidence of the higher asthma morbidity experienced by children who reside in poor-urban areas.⁶⁻⁹ However, less is known about the relationship between asthma morbidity and poor-urban residence with respect to other factors such as race, ethnicity, or other individual characteristics. It is unclear whether the high asthma morbidity experienced among children in poor-urban areas is attributable to underlying individual characteristics or whether poor-urban geographical residence is an independent risk factor for poor asthma outcomes. Preliminary evidence in a subset of children receiving Medicaid suggests that poor-urban residence is independently associated with asthma-related emergency department (ED) visits and hospitalizations even after controlling for race/ethnicity, sex, and age.¹⁰ These results are contrary to the findings related to asthma prevalence and suggest that the relationship between poor-urban residence and individual characteristics such as race and ethnicity may be different for asthma morbidity among children with preexisting asthma. More information is needed to fully comprehend this relationship and inform public health efforts. Our study aims to assess the association between poor-urban residence and individual characteristics such as race, ethnicity, comorbidity, and smoking status with a broad array of asthma treatment and morbidity measures across all states in a nationally representative population of children (including privately insured, publicly insured, and uninsured).

METHODS

This study was a retrospective analysis of cross-sectional data for children aged 1 to 17 years in the nationally representative 2000-2014 Medical Expenditure Panel Survey (MEPS). Asthma treatment and indicators of control were compared for children with asthma by place of residence. Several years of data were chosen to ensure adequate sample size for some of the relatively rare outcomes (eg, inpatient [IP] visits), especially when stratified by place of residence.

The data from MEPS 2000-2014 had consistent asthma measures and questions as well as sample design and could be combined without inconsistency.

Poor-urban tract residence

Previous publications have most often referred to poor-urban areas as “inner-city,” and have used the following standardized definition^{4,11}: residence in a census tract with both (1) large metro Metropolitan Statistical Area (MSA) (“urban”) and (2) more than 20% of households below the federally defined poverty level (“poor”). Our method of categorizing poor-urban residence is consistent with previous research.^{4,10,11} Census tract and county Federal Information Processing Standard (FIPS) codes were available for each individual in MEPS as restricted data. “Restricted data” are data that are available only onsite at the Agency for Healthcare Research and Quality (AHRQ) Data Center headquarters in Maryland. Exogenous data (non-MEPS) from the National Center for Health Statistics (NCHS) Urban-Rural Classification Scheme for Counties were used to identify the metropolitan status (MSA) of the county of residence by county FIPS code. These data were merged with the MEPS data by county FIPS code to determine metropolitan status (MSA) of the county of residence. US Census Data were used to determine the percentage of residents below the federal poverty level for each census tract. This was linked by census tract to each child in MEPS to determine the poverty status of the tract of residence. The NCHS Urban-Rural Classification Scheme for Counties classifies counties by MSA into (1) large metro, central, (2) large metro, fringe, (3) medium metro, (4) small metro, (5) micropolitan, and (6) noncore on the basis of population density and other measures of urbanization. Generally, large metro central is considered the urban core (“urban”) and includes more than 1 million people; large metro fringe is thought to be equivalent to “suburban” and includes more than 1 million people on the fringe of a metropolitan area. Medium metro generally includes 250,000 to 1 million people in a core area. Small metro generally includes less than 250,000 in a core area. “Micropolitan” and “noncore” are considered to be rural areas. These MSA categories were combined with the data on poverty (“poor”: >20% of households below the federally defined poverty level) to create mutually exclusive categories. Linkage of the 3 data sources provides a unique combination of nationally representative asthma control and treatment estimates by urban and poverty status of the child’s place of residence (MEPS, NCHS Urban-Rural Classification Scheme for Counties, and the US Census).

Indicators of asthma control and treatment

Indicators of poor asthma control included measures used in previous publications¹²: (1) asthma exacerbation in previous year (self-reported; survey); (2) use of more than 3 canisters of short-acting beta agonist (SABA) in the previous 3 months (self-reported; survey); or (3) asthma-specific ED visit or hospitalization within the year (utilization-based). Asthma treatment outcomes included 1 self-reported response about the use of daily preventive asthma controller medication, including both oral medicine and inhalers. In addition, 4 outcome measures based on actual prescription drug use were constructed: (1) inhaled corticosteroids (including combination products with long-acting beta agonists); (2) SABA; (3) controller medications (including leukotrienes, theophylline, mast cell stabilizers, and inhaled corticosteroids); and (4) controller-to-total ratio of 0.7 or more, the ratio of controller medications/(controller + SABA).

These indicators of poor control were chosen on the basis of what was substantiated by previous research and available in MEPS data. Asthma control is defined as the extent to which asthma therapy minimizes symptoms and meets therapy goals.¹³ Impairment and risk are the 2 domains of asthma control. *Impairment* refers to asthma-related symptoms and limitations. The likelihood of future exacerbations and progressive loss of lung function is referred to as risk.¹³ Although the use of standardized asthma control instruments such as the Asthma Control Questionnaire may be preferred, these instruments were not included in the MEPS data. In lieu of standardized instruments, previous research has used proxy measures of impairment, symptoms, risk, and exacerbations. Previous research has shown that excessive SABA is a good indicator of symptom control, and hospitalizations, ED visits, and self-reported exacerbations are valid indicators of risk.¹⁴⁻¹⁸ In addition, a ratio of controller to total medications of 0.7 or more has been shown to be predictive of poor asthma control leading to exacerbations.¹⁹

Data source

MEPS is a nationally representative survey of the US civilian noninstitutionalized population that incorporates survey data from patients and families, medical providers, insurance providers, and employers to provide a comprehensive portrait of medical resource utilization, the frequency of utilization, costs of provided services, how these costs are paid, and the extent and scope of health insurance coverage for US residents. Each individual in MEPS is followed for a 2½-year period in an overlapping panel design. Respondents complete a battery of MEPS questions in each round, with 3 rounds per year. The questions are typically completed on behalf of children by a parent or proxy. MEPS constructs annual data files from the panel survey. The 2000-2014 annual data were stacked into a cross-sectional analysis. The use of multiple years of data across 15 years was necessary to have adequate sample size for the end points assessed.

The MEPS Household Component (HC) contains detailed self-reported information on demographic and socioeconomic characteristics, health conditions, insurance status, smoking status, and utilization and cost of health care services. In addition, MEPS treats asthma as a priority condition and contains several questions specific to asthma. The MEPS Medical Provider Component is a follow-back survey that collects detailed information from a sample of pharmacies and health care providers used by MEPS respondents. The Medical Provider Component supplements and validates information on medical utilization, pharmacy events, and expenditures.

Each annual MEPS-HC sample size is about 15,000 households. Data must be weighted to produce national estimates. The set of households selected for each panel of the MEPS HC is a subsample of households participating in the previous year's NHIS conducted by the NCHS, which is part of the Centers for Disease Control and Prevention. The NHIS sampling frame provides a nationally representative sample of the US civilian noninstitutionalized population and reflects an oversample of blacks, Hispanics, and Asians. For over 50 years, the US Census Bureau has been the data collection agent for the NHIS. Further details on MEPS are available at www.meps.ahrq.gov.

Asthma and other characteristics

There were 2 MEPS survey questions used to identify the presence of current asthma in conjunction with *International Classification of Diseases, Ninth Revision (ICD-9)* diagnosis code 493

“Asthma.” The first question was, “Have you ever been diagnosed with asthma?” The second, follow-up question, was, “Do you still have asthma?” Children were classified as having current asthma if the response was positive for both questions. If the response was negative to still having asthma, but there was health care use with *ICD-9* diagnosis code 493 Asthma, the child was classified as having current asthma. Children who had a positive response to ever having asthma but a negative response to still having asthma and no health care use with *ICD-9* diagnosis code 493 were excluded from the analysis because their asthma status was ambiguous.

Other characteristics available in MEPS were included in the regression analyses as covariates. These included age, sex, race, ethnicity, insurance, region, number of chronic conditions excluding asthma (NCC), year of the survey, and the presence of a smoking family member. The NCC variable was constructed from all reported chronic *ICD-9* codes to capture comorbidity burden. Age was separated into 3 categorical variables: 1 to 5 years, 6 to 11 years, and 12 to 17 years.

Statistical methods

All analyses incorporate MEPS sample and variance weights to ensure nationally representative, annualized estimates. Unadjusted descriptive statistics are presented by all combinations of MSA and census tract poverty status. For the main analyses, all outcomes were dichotomous (yes/no) and logistic regression was conducted to compare poor-urban tract residence to all others (collapsed) controlling for insurance, race, sex, age, ethnicity, region, comorbidity, smoking family member, and year of survey. This research was approved by a centralized institutional review board as well as the AHRQ Research Review Board. All analyses were conducted at AHRQ headquarters.

RESULTS

There were 930,882 children with asthma living in poor-urban areas in 2014 in the United States (Table I). The greatest percentage of children with asthma lived in urban and suburban nonpoor areas in 2014 (22.2% and 22.7%, respectively). Overall, there were 8.4 million children with asthma in the United States in 2014. Table II provides the percentages of individuals across all neighborhood poverty and urban combinations. A higher percentage of children with asthma residing in poor-urban tracts were black and Hispanic compared with other residential tracts (Table II). More than half (53%) of children with asthma residing in micropolitan poor areas have a family member who smokes compared with only 26% of children residing in urban and suburban nonpoor tracts, with other residential areas falling in between. More than half (52.7%) of the children with asthma residing in noncore poor tracts have other comorbidities in addition to asthma.

Children with asthma residing in poor-urban areas have a high prevalence of poor asthma control and treatment indicators (Table III). They have the highest percentage of ED/IP visits (9.2%), and second highest excessive use of SABA (6.2%), lowest use of controller medications (25.5%), and second lowest percent with a controller-to-total ratio of 0.7 or more (34.2%) (Table III). Children residing in noncore poor areas also had poor outcomes with a high percentage using SABA (48.3%) and excessive SABA (7.1%) and a very small percentage with a controller-to-total ratio of 0.7 or more (35.7%) compared with children residing in other areas.

TABLE I. Children with and without asthma by place of residence

Place of residence	No asthma			Asthma		
	Sample (MEPS 2000-2014)*	Total in US (MEPS 2014)†	% (MEPS 2014)‡	Sample (MEPS 2000-2014)*	Total in US (MEPS 2014)†	% (MEPS 2014)‡
Urban poor tract	15,751	5,592,100	9.2%	2,196	930,882	11.1%
Urban not poor tract	27,628	11,444,051	18.8%	3,083	1,863,905	22.2%
Suburb poor tract	2,323	1,688,401	2.8%	373	305,388	3.6%
Suburb not poor tract	22,375	14,537,411	23.9%	2,925	1,900,906	22.7%
Medium metro poor tract	7,309	3,010,724	4.9%	1,046	472,114	5.6%
Medium metro not poor tract	15,912	9,584,206	15.7%	2,036	1,061,957	12.7%
Small metro poor tract	2,131	935,974	1.5%	373	224,694	2.7%
Small metro not poor tract	7,281	5,229,033	8.6%	866	546,307	6.5%
Micropolitan poor tract	3,772	1,708,498	2.8%	530	182,022	2.2%
Micropolitan not poor tract	7,326	4,005,151	6.6%	955	429,741	5.1%
Noncore poor tract	2,409	1,567,209	2.6%	317	204,079	2.4%
Noncore not poor tract	3,624	1,637,804	2.7%	352	262,491	3.1%
Total	117,841	60,940,562	100%	15,052	8,384,486	100%xxx

*Number of individuals with positive person-weights in MEPS 2000-2014 data.

†Weighted number of individuals in MEPS 2014 data using national extrapolation weights.

‡Weighted percentages of individuals in MEPS 2014 data.

TABLE II. Sample characteristics of children with asthma by place of residence*

Place of residence	Black	White	Other race	Asian	Native American	Female	Hispanic	NCC ≥ 1	NCC = 0	Smoking family member
Urban poor tract	52.3%	42.4%	2.4%	1.6%	1.3%	41.9%	38.1%	33.5%	66.5%	33.4%
Urban not poor tract	24.7%	65.1%	4.1%	5.9%	0.3%	40.8%	24.8%	39.3%	60.7%	25.5%
Suburb poor tract	45.7%	44.5%	4.3%	3.9%	1.7%	38.5%	23.4%	42.3%	57.8%	39.3%
Suburb not poor tract	16.9%	74.4%	4.7%	3.7%	0.3%	40.8%	12.7%	49.0%	51.0%	25.6%
Medium metro poor tract	35.0%	55.8%	5.9%	1.1%	2.2%	42.0%	37.6%	44.0%	56.0%	35.7%
Medium metro not poor tract	13.4%	78.2%	5.0%	2.6%	0.9%	40.9%	15.0%	48.5%	51.5%	28.0%
Small metro poor tract	39.0%	49.6%	7.5%	2.8%	1.2%	38.2%	18.8%	40.3%	59.7%	40.3%
Small metro not poor tract	12.4%	82.5%	2.4%	1.2%	1.5%	37.5%	13.4%	47.3%	52.7%	37.8%
Micropolitan poor tract	33.5%	51.9%	4.2%	3.2%	7.3%	42.6%	13.6%	45.1%	54.9%	52.6%
Micropolitan not poor tract	7.3%	87.6%	3.3%	0.9%	0.9%	39.4%	7.0%	52.4%	47.6%	38.4%
Noncore poor tract	27.1%	68.8%	1.7%	0.0%	2.4%	33.3%	12.9%	52.7%	47.4%	34.9%
Noncore not poor tract	10.9%	87.1%	0.7%	0.3%	1.1%	39.5%	4.1%	51.1%	49.0%	39.6%

*Weighted percentages among those with positive person-weights.

In unadjusted analyses, children with asthma residing in poor-urban areas had lower odds of using controller medications and having a controller-to-total medication ratio of 0.7 or more (Figure 1). They also had greater odds of having an ED/IP visit and excessive SABA use, but lower odds of reporting having had an asthma attack. Many of these associations remained even after controlling for insurance, race, sex, age, ethnicity, region, comorbidity, smoking family member, and year of survey. Children with asthma residing in poor-urban areas had lower odds of using controller medications (odds ratio [OR] = 0.77) and having a controller-to-total medication ratio of 0.7 or more (OR = 0.75) compared with other residential tracts (Figure 2). In addition, they had higher odds of having an ED/IP visit (OR = 1.3). However, children from poor-urban tracts were less likely to report having had an asthma attack in the previous year (OR = 0.75). Excessive SABA use was no longer statistically significant after controlling for covariates. The odds of reporting using daily preventive medication was not statistically significantly different by residence in

either unadjusted or adjusted models. In multivariate models, there were several covariates that were significantly associated with asthma treatment and outcomes. After controlling for poor-urban residence and other covariates, black race was associated with greater odds of excessive SABA use (OR = 2.11) and ED/IP visit (OR = 2.03) as well as lower odds of using controller medication (OR = 0.77) and controller-to-total ratio of 0.70 or more (OR = 0.50). Hispanic ethnicity was associated with greater odds of excessive SABA use (OR = 2.91) and ED/IP visit (OR = 1.41) as well as lower odds of having a controller-to-total ratio of 0.70 or more (OR = 0.57). Asian race was also associated with excessive SABA use (OR = 2.64). Having a smoking family member was associated with lower odds of controller medication use (OR = 0.73), having a controller-to-total ratio of 0.7 or more (OR = 0.75), and self-reporting of having used a daily preventive medication (OR = 0.83). Hispanic children (OR = 0.86) and those with a smoking family member (OR = 0.89) were less likely to self-report having had an asthma attack in the previous year.

TABLE III. Treatment and indicators of asthma control among children with asthma by place of residence*

Place of residence	Asthma attack	SABA > 3 can	Current use prev med daily	Asthma ED or IP	ICS Use (any)	SABA Use (any)	Controller use (any)	Control to total Rx ratio of ≥ 0.70
Urban poor tract	43.2%	6.2%	19.8%	9.2%	19.1%	43.8%	25.5%	34.2%
Urban not poor tract	50.8%	4.8%	19.3%	5.4%	21.1%	42.0%	29.5%	44.3%
Suburb poor tract	50.5%	4.3%	18.7%	5.2%	19.2%	40.7%	28.1%	45.1%
Suburb not poor tract	52.2%	3.4%	23.7%	4.8%	27.4%	42.8%	36.8%	51.1%
Medium metro poor tract	47.5%	5.9%	20.1%	6.1%	23.1%	44.0%	31.3%	38.8%
Medium metro not poor tract	49.3%	4.6%	24.4%	3.8%	26.2%	45.1%	36.7%	51.1%
Small metro poor tract	47.5%	2.7%	20.2%	7.5%	24.6%	46.2%	34.1%	40.3%
Small metro not poor tract	51.5%	3.6%	24.2%	5.8%	26.2%	41.8%	36.6%	48.7%
Metropolitan poor tract	43.3%	4.6%	22.1%	3.8%	26.2%	42.9%	31.9%	37.2%
Metropolitan not poor tract	50.5%	5.1%	21.5%	5.2%	26.5%	40.2%	35.4%	54.1%
Noncore poor tract	55.2%	7.1%	27.3%	5.5%	24.5%	48.3%	38.2%	35.7%
Noncore not poor tract	50.1%	3.2%	19.4%	6.9%	25.7%	42.3%	36.3%	44.8%
Total	49.9%	4.5%	22.0%	5.4%	24.5%	43.0%	33.5%	47.1%

ICS, Inhaled corticosteroid; Med, medications; Prev, preventive.

*Weighted percentages among those with positive person-weights.

DISCUSSION

Results from this nationally representative study of children with asthma suggest that poor-urban residence is associated with significant health disparities in the form of suboptimal treatment and indicators of poor asthma control. Children residing in poor-urban neighborhoods had higher odds of ED and hospital visits, SABA use consistent with very poorly controlled asthma (>1 canister per month), and lower odds of using controller medications generally as well as lower odds of using controller medications optimally (as measured by the controller-to-total ratio of ≥ 0.7). The association between poor-urban residence and asthma control and treatment was attenuated slightly by controlling for a wide array of individual characteristics (insurance, race, sex, age, ethnicity, region, comorbidity, smoking family member, and year of survey). However, the associations remained statistically significant for many outcomes and suggest that poor-urban residence may be independently associated with asthma control and treatment patterns among children in the United States (The following outcomes remained statistically significant after controlling for covariates [Figure 2]: odds of using controller medications, having a controller-to-total medication ratio of ≥ 0.7 , and having an ED/IP visit).

Research has documented higher asthma prevalence and worse morbidity among residents of poor-urban ("inner-city" in the past) areas for decades.¹⁻³ The nature of this association is complex and largely interdependent with other individual factors such as race and ethnicity, among many others. Certain race and ethnicity characteristics have been shown to be associated with asthma incidence and morbidity in many previous studies.²⁰ A recent study by Keet et al⁴ improved our understanding of the relationship between poor-urban residence and asthma prevalence. They showed that although the prevalence of asthma was higher in poor-urban areas, this was due largely to race and ethnicity characteristics concentrated in these areas. After controlling for race and ethnicity, the prevalence of asthma was not significantly higher in poor-urban areas.

Our study provides novel information about the association between asthma morbidity and poor-urban residence in a nationally representative sample. Although previous studies⁴ suggest that the prevalence of asthma is more likely to be influenced

by race and ethnicity than by poor-urban residence itself, the relationship between asthma morbidity and poor-urban residence, race, ethnicity, or other characteristics was not previously well understood. Many studies have found greater asthma morbidity among residents of poor-urban areas, but the relative influence of other characteristics such as race/ethnicity was not explicitly studied. One recent study by Keet et al¹⁰ examined this relationship in a subset of children who were Medicaid recipients. The authors found that poor-urban residence was associated with greater odds of asthma-related ED visits and hospitalizations among children with asthma receiving Medicaid even after controlling for race/ethnicity, sex, and age. This study improved our understanding of how poor-urban residence and race/ethnicity independently influence the risk of asthma exacerbations requiring ED or hospital visits among children receiving Medicaid in select states. However, the study sample represented a very unique subpopulation (Medicaid) that may not be generalizable to the wider population of children in the United States or even Medicaid recipients in other states. Our study is novel for several reasons. First, our study included a nationally representative population of children across the United States including Medicaid and all other insurance types (even self-pay). In addition, the results include a more comprehensive array of asthma outcomes and potential clinical explanations for exacerbations, such as suboptimal controller medication use, and how these factors interact with poor-urban residence, race, ethnicity, and other individual patient characteristics. The previous study by Keet included ED and IP visits as the sole outcomes. In addition to ED and IP visits, our study included more comprehensive outcomes, including indicators of poor control (use of >3 canisters of SABA in 3 months and asthma attack) and treatment (use of controller medications and the ratio of controller-to-total prescriptions of ≥ 0.7). Unlike previous studies, our study also included other important confounders such as comorbidity and smoking status. Our results showed that these are important confounders of the relationship between poor-urban residence and asthma morbidity.

Understanding what factors underlie the "epidemic" of asthma prevalence and morbidity in poor-urban areas is crucial to inform public health efforts to combat health disparities. The first level

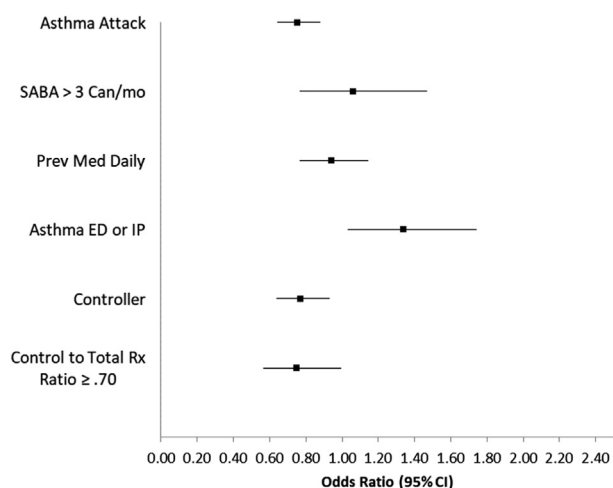


FIGURE 1. Asthma control and treatment by poor-urban residence among children with asthma: unadjusted regression results. *Med*, Medications; *Prev*, preventive.

of understanding this relationship is to recognize that the factors that influence the development of asthma may be different than those that affect asthma morbidity. Previous research has shown that poor-urban residence is not independently associated with asthma prevalence but, rather, race and ethnicity mediate the association.⁴ Hence, our research focuses only on asthma morbidity. The next level is to disentangle the effect of geographic factors from individual characteristics associated with asthma morbidity among children living in poor-urban areas. The multifactorial components of asthma morbidity among disadvantaged communities are complex.²⁰ Geographic factors associated with poor-urban environments that may contribute to poor asthma outcomes include exposure to indoor and outdoor pollution such as proximity to highways or diesel particulates, pest allergens such as cockroach or mouse allergens, inadequate access to primary/specialty care, lack of home ownership, poor diet related to access, the built environment, or violence and other psychological stress.²¹⁻²⁴ Many of these factors are associated with individual socioeconomic characteristics. Our results provide novel insights into how poor-urban residence may contribute to asthma morbidity by explicitly controlling for many individual-level confounders such as race, sex, ethnicity, region, comorbidity, smoking family member, and insurance. Our finding that poor-urban residence continued to be statistically significantly associated with indicators of poor asthma control after adjusting for these confounders provides preliminary evidence that the geographic factors discussed above may be important contributors to asthma morbidity. Future studies explicitly assessing these geographic factors are needed to further improve understanding of this relationship and thereby inform public health efforts to combat health disparities. For example, it would be beneficial to specifically examine whether living with exposure to geographic factors listed above (pollution, pest allergens, etc) impact asthma control after controlling for individual-level characteristics (race, ethnicity, smoking, etc).

In addition to these potential geographic factors associated with poor-urban residence, individual characteristics are known to be strongly associated with asthma morbidity. The results of

our study also show that individual characteristics such as race, ethnicity, and having a smoking family member were independently and significantly associated with asthma treatment and indicators of poor control. Furthermore, the addition of these individual-level characteristics attenuated the effect of poor-urban residence for most outcomes and completely mediated the effect of poor-urban residence on excessive SABA use. These individual-level characteristics had a stronger association with indicators of asthma control and treatment than poor-urban residence (as seen from the greater magnitude of the OR and smaller *P* values compared with poor-urban residence). These results are consistent with previous studies showing the strong association between race and ethnicity and asthma control.²⁵⁻²⁸ However, unlike many of these studies, our study explicitly controlled for poor-urban residence.

Two other factors are associated with asthma morbidity: comorbidities and exposure to smoking family members. Another distinguishing characteristic of this research is the explicit inclusion of these 2 factors that have not been included in previous examinations. Comorbidities are known to increase the severity and difficulty of maintaining asthma control. This research provides important information about comorbidity among children with asthma residing in poor-urban areas. Sample characteristics suggest that the nonasthma comorbidity burden was not more prevalent in the poor-urban population than in children residing in other areas (Table II; NCC $\geq 1 = 33.5\%$). The inclusion of comorbidity as a covariate did not appear to attenuate the relationship between the outcomes and poor-urban residence. The presence of a smoking family member is also strongly associated with asthma control. The percentage of children residing in poor-urban areas with a smoking family member did not appear much higher than average (Table II; 33.4%). However, the presence of a smoking family member did appear to be statistically significantly associated with some outcomes (Figure 2). Although race and ethnicity have been shown to mediate the effect of asthma prevalence among poor-urban residents, previous studies have not included comorbidity or family member smoking status. This underscores the importance of controlling for confounding characteristics in exploring the association between asthma morbidity and poor-urban residence.

Asthma control is defined as the extent to which asthma therapy minimizes asthma symptoms and meets therapy goals.¹³ It is composed of 2 domains: impairment (asthma-related symptoms and limitations experienced by the patient) and risk (the likelihood of future exacerbations and progressive loss of lung function).¹³ Although the indicators of asthma control used in this analysis are not direct clinical measures of control, there is literature supporting their use as acceptable proxy measures of control. Previous research has shown that excessive SABA use is consistent with poor asthma symptom control, and hospitalizations, ED visits, and self-reported exacerbations are good proxies for risk.¹⁴⁻¹⁸

Measures of asthma control based on self-report were not always consistent with utilization-based measures for certain groups of children. In particular, some groups of children who had indicators of poor control were less likely to report having had an asthma attack in the previous year. For example, Hispanic children were less likely to report having had an asthma attack in the previous year, but more likely to have had evidence of an ED/IP visit in the previous year. This difference may be a reflection of lack of understanding or other sources of recall bias

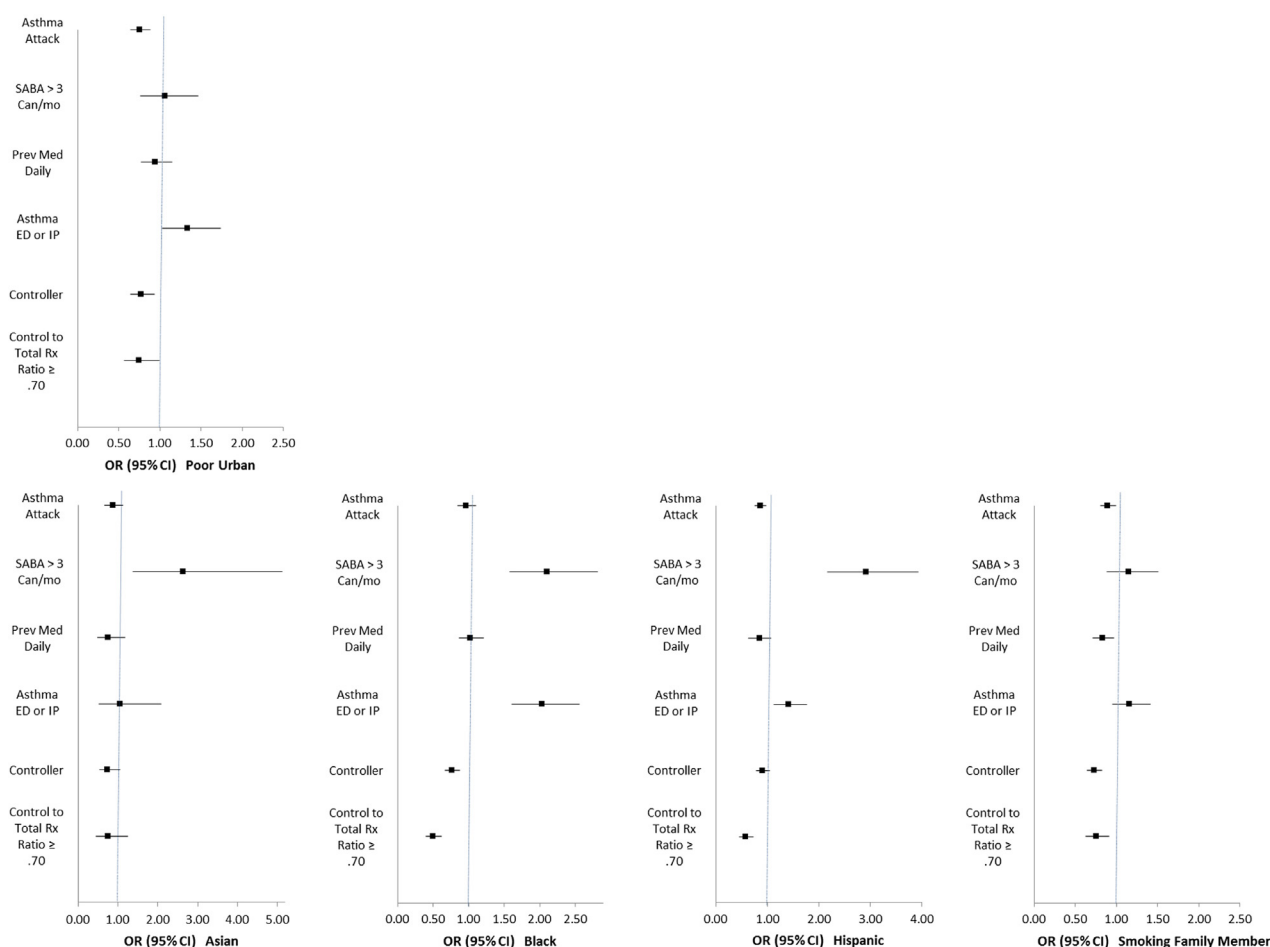


FIGURE 2. Asthma control and treatment by poor-urban residence, race, ethnicity, and family smoking status among children with asthma: adjusted regression results. *Med*, Medications; *Prev*, preventive.

that differentially affect different groups of children. In addition, the prevalence of having had an asthma attack among children with asthma was very high (close to half of children reported having had an asthma attack—Table III) compared with ED/IP visits (4%-9%). Hence, although the characteristic was statistically associated, the population experiencing each outcome was quite different.

This study has significant clinical ramifications. Asthma morbidity can have lasting effects on lung function.^{5,29} Persistent wheeze is associated with reduced lung growth and function among children during adolescence.³⁰ Asthma morbidity has been shown to follow a pattern of airway obstruction that gets worse as age progresses.³¹ Reduced lung function in adults is associated with asthma morbidity in childhood.³² This study shows that there are health disparities in asthma morbidity and treatment based on a child's residence, race, and ethnicity. Given the natural history of asthma morbidity, this implies that the health disparities will continue into adulthood if not addressed during childhood. Increased attention and vigilance toward understanding and combating modifiable geographic and individual challenges is paramount.

Study limitations

There are limitations associated with the study design and data source. This was a cross-sectional study and, therefore, could only examine associations, not causation. To have adequate sample size, the data spanned several years. Although the study controlled for the year of the survey, it is possible that the relationships changed over time. Several outcomes and independent variables were based on self-report. These measures may be subject to misclassification and/or recall bias. Furthermore, the survey was completed on behalf of children by a parent or proxy. This may have affected the accuracy of responses and these inaccuracies may be exacerbated by proxy response of caregivers. MEPS does not capture information about asthma severity or direct clinical measures of asthma control. The indicators of poor control and treatment chosen in this study were based on what was available in the MEPS. There may be other important measures of asthma control such as spirometry and asthma control questionnaires; however, these were not included in the MEPS. In addition, the potential exists for bias due to differences in the individuals who agreed to participate in, and complete, the MEPSs.

Despite these limitations, MEPS offers the advantage of being nationally representative and enabling linkage to US Census data to determine poor-urban status. MEPS also includes detailed sociodemographic characteristics and questions specific to asthma control and treatment, making it uniquely appropriate for this research question.

Results from this nationally representative study of children with asthma suggest that poor-urban residence is independently associated with significant health disparities in the form of sub-optimal treatment and indicators of poor asthma control. Although the association between poor-urban residence and asthma control and treatment was attenuated slightly by controlling for a wide array of characteristics, the associations remained statistically significant for many outcomes and suggest that poor-urban residence is independently associated with asthma control and treatment patterns among children with asthma in the United States.

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