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## Pediatric Asthma Health Disparities: Race, Hardship, Housing, and Asthma in a National Survey

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### Abstract

**Objectives**—We sought to determine if racial disparities in pediatric asthma are explained by material hardship and home ownership.

**Methods**—We performed a secondary analysis of the 2011 American Housing Survey. 33,201 households with children age 6-17 years were surveyed regarding childhood asthma diagnosis and ED visits for asthma (for the youngest child with asthma in the household). Material hardship included poor housing quality, housing crowding, lack of amenities, and no vehicle access. We used logistic regression to determine the association between race, material hardship, and asthma diagnosis or ED visits, adjusting for potential confounders.

**Results**—Non-Hispanic Black heads of household had a higher odds of having a child diagnosed with asthma in the home in comparison to non-Hispanic White heads of household (OR 1.72, 95%CI 1.50-1.96), and a higher odds of ED visits for asthma (OR 3.02, 95%CI 2.29-3.99). The race-asthma association was decreased but not eliminated after adjusting for material hardship and home ownership (ED Visit AOR 2.07, 95%CI 1.50-2.86). Poor housing quality was independently associated with asthma diagnosis (AOR 1.45, 95%CI 1.28-1.66) and ED visits (AOR 1.59, 95%CI 1.21-2.10). Home ownership was associated with a lower odds of asthma-related ED visits (AOR 0.62, 95% CI 0.46-0.84).

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**Conclusions**—Observed racial disparities in pediatric asthma are lessened after controlling for material hardship. Poor housing quality in particular is strongly associated with asthma morbidity. Policy makers could target improving housing quality as a means of potentially reducing asthma disparities.

### Keywords

Asthma; Healthcare Disparities; Housing; Pediatrics; Poverty

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### Introduction

Although racial/ethnic disparities in pediatric asthma are well documented<sup>1</sup>, few interventions have been shown to effectively bridge these disparities.<sup>2</sup> Non-Hispanic Black children have higher rates of asthma diagnosis, asthma morbidity, hospitalizations for asthma, and asthma mortality than non-Hispanic white children.<sup>3,4</sup> Multiple factors have been proposed to explain these inequities including health care access, health literacy, parental stress or depression, clinician bias, and genetic risk factors.<sup>5</sup> It has also been suggested that most of the observed racial/ethnic disparities may stem from socioeconomic differences between groups, and that the observed contribution of race/ethnicity to poor asthma outcomes would diminish if we could more accurately capture socioeconomic status (SES).<sup>6,7</sup>

It is increasingly recognized that SES is a multidimensional concept and that adjusting for a single measure of SES (e.g., income) may not be sufficient to capture variation in SES between racial and ethnic groups.<sup>6</sup> For example, although non-Hispanic Black workers have made modest income gains since the 1960s, the net-worth (wealth) of Black households has actually fallen in the past three decades, while the net worth of non-Hispanic White households has increased by 11%.<sup>8</sup> Recognizing the limitations of using income as a sole measure of SES, some studies have attempted to characterize the financial hardships that families face using more robust experiential measures, sometimes termed material hardship.<sup>9,10</sup> Although there is no universally accepted definition of material hardship, most indices aim to capture families' daily experiences, living conditions, and whether basic needs are met.<sup>9</sup> Material hardship may include both poverty-related conditions that lead to known asthma triggers (e.g. poor housing quality leading to pest exposure) as well as measures of deprivation that may contribute indirectly to poor asthma control (e.g. lack of access to transportation). Home ownership, or lack there-of, is not typically considered a marker of material hardship, but because homes are the primary asset for many Americans, home ownership is an easy, though imperfect, proxy for wealth.<sup>11–13</sup>

There is a rich literature describing the relationship between race/ethnicity, socioeconomic status, and poor health outcomes (particularly asthma). For example, material hardship has been linked to poor health in children<sup>14</sup>, while home ownership has generally been shown to be associated with improved health outcomes.<sup>15,16</sup> Asthma specifically has been linked to poor housing quality, particularly in regional studies and studies of young children.<sup>17–19</sup> Prior research has demonstrated that low-income Black families have higher rates of

material hardship than low-income White families, and that there are substantial racial/ethnic gaps in home ownership.<sup>10,11</sup>

Although racial/ethnic disparities in asthma outcomes have been thoroughly studied, the following questions are unresolved – Can socioeconomic factors explain racial/ethnic disparities, or are they related to inherent factors (e.g., genetic predisposition) that differ between racial/ethnic groups? Our ability to understand the reasons for racial/ethnic disparities is limited by how well we can measure the material hardships that may explain these differences. With more accurate measurements of material hardship, we may better understand the broader socioeconomic context surrounding children with asthma and the reasons why asthma disparities remain such a persistent problem. Wright & Subramanian proposed a framework to conceptualize these socioeconomic dynamics.<sup>20</sup> In this framework, asthma disparities are explained by a complex interplay between structural factors (e.g., low income), physical conditions (e.g., dilapidated housing), and social processes leading to differential exposures and host interactions that increase the risk of asthma and asthma-related morbidity. Many of the factors identified in their framework fall under the umbrella of material hardship.

No studies to our knowledge have examined the intersection of race, material hardship, and home ownership in pediatric patients with asthma on a national scale. The 2011 American Housing Survey provides a unique opportunity to study these relationships, as it is a nationally representative survey that includes robust housing and hardship metrics as well as data related to pediatric asthma, race/ethnicity, and SES. The primary aim of this study was to examine race/ethnicity-related pediatric asthma disparities in the context of broader experiential measures of socioeconomic status (material hardship) and home ownership on a national scale. We hypothesized that income and education would incompletely explain the asthma-race relationship, and that material hardship and home ownership would explain an additional proportion of these disparities. Our secondary aim was to identify potential targets for intervention to improve health disparities—specifically, to determine which measures of material hardship and home ownership, if any, are independently associated with childhood asthma diagnosis and morbidity. We hypothesized that material hardship measures (poor housing quality, crowding, lack of amenities, and no vehicle access) would be associated with increased asthma diagnosis and morbidity independent of race, income, and education whereas home ownership would be associated with lower rates of diagnosis and asthma morbidity.

## Methods

### Study Design and Population

We performed a secondary analysis of publically available data from the 2011 American Housing Survey (AHS).<sup>21</sup> This survey was funded by the Department of Housing and Urban Development and conducted by the United States (US) Census Bureau. It is the most comprehensive national housing survey in the US. The 2011 survey was chosen for analysis because it is the only year to include questions related to pediatric asthma. The survey included data from 155,000 units, selected to represent a cross-section of all housing in the US and weighted to be representative of US housing units. The overall response rate was

87%.<sup>22</sup> Respondents were interviewed between July and December 2011. Census employees performed data collection by telephone or in-person via a laptop survey questionnaire.<sup>21</sup> Housing units were included in our analysis if heads of household answered questions regarding pediatric asthma. These questions were asked of units occupied by families who had at least one child age 6-17 living in the home.

### Variables of Interest

The outcome variables of interest included questions related to pediatric asthma designed by the 2011 AHS. Respondents living in households with children 6 to 17 years of age were asked the following: “Has a doctor or other health professional ever told you that any of your children who have lived in the home have asthma?” and “During the last 12 months, has the youngest household member [who has been diagnosed with asthma] had to visit an emergency room because of asthma?”

Material hardship measures were selected by identifying those variables within the survey that served as markers for material hardship as defined by U.S. Department of Health and Human Services.<sup>9</sup> Material hardship variables included poor housing quality (the presence of any of the following—cracks in walls/floors/windows, broken plumbing, or exposed wires), housing crowding (>2 people per bedroom), lack of household amenities (whether the unit lacked any of the following: a working washing machine, dishwasher, or refrigerator), and no vehicle access (no vehicle available for household use). Home ownership status was determined by asking whether the unit was “owned or being bought by someone in your household”.

Sociodemographic characteristics were in reference to the head of household. For the purposes of our analysis, relevant demographic variables included household race/ethnicity (non-Hispanic White, non-Hispanic Black, Asian, Hispanic, other (includes American Indian, Alaskan Native, Pacific Islander, and mixed-race)), and head of household age and sex. Additional socioeconomic measures were total household income as a percentage of the federal poverty level<sup>23</sup> (<=100%, 101-249%, 250-499%, >=500%) and head of household education (less than high school, high school graduate, some college or other, bachelor's degree or higher). Other control variables included census division<sup>21</sup>, metropolitan status<sup>21</sup>, number of children in the home (age 6-17) and household exposures. To assess household exposures (mice/rat, cockroaches, and mold) residents were asked whether the respondent noted mice/rat, cockroaches, and mold exposures in the past year (e.g. “In the last 12 months, was there mold covering an area greater than or equal to the size of an 8 1/2” × 11” piece of paper in the home?”). Smoke exposure was assessed using the question, “Do any members of the household smoke tobacco inside the home?”

### Statistical Analysis

Bivariate comparisons of asthma diagnosis over various demographic, social, and economic factors were analyzed with chi-squared tests. We then used multivariable logistic regression to determine the association between household race/ethnicity and asthma diagnosis or ED visits. We created additional models to assess the association between material hardship/home ownership and asthma diagnosis or ED visits. We created an unadjusted model as well

as multiple multivariable models. We compared potentially collinear variables using tolerance and variance inflation factors and did not find evidence of collinearity (data not shown). The SES/demographic adjusted model in Table 3 included the following variables: household race/ethnicity, household income, education, census region, and number of children in the home. Similar SES/demographic adjusted models in Table 4 included these same variables, as well as each relevant material hardship or home ownership variables. The hardship/home ownership adjusted models (Model 1 in Tables 3 and 4) included all SES and demographic variables and additionally all material hardship measures (poor housing quality, crowding, limited amenities, no vehicle access) as well as home ownership. In Table 4, we created a final exposure adjusted model (Model 2) that included all variables in Model 1 as well as household exposures (cigarette smoke, mold, mice, and cockroaches).

Chi-squared test was used to determine if housing quality differed by home ownership status and if home ownership differed by race/ethnicity. We used balanced replicate weights provided by the American Housing Survey; use of these weights accounts for the complex survey design of this study.<sup>21</sup> Analyses were conducted in STATA 11.<sup>24</sup>

## Results

### Study Sample Demographics and Diagnosis of Asthma, Asthma ED Visits

Characteristics of the entire weighted study sample are shown in Table 1. Our analysis included 33,201 households containing at least one child 6-17 years old. Approximately 20% of households had a child living in the home who had been diagnosed with asthma. A small fraction of households (2%) indicated that the youngest member of the household with asthma had visited the ED for asthma in the past year. The study sample was primarily non-Hispanic White, approximately 16% of respondents were non-Hispanic Black, and 21% Hispanic. Approximately 20% of the study sample indicated their annual household income as being at or below the poverty level.

### Material Hardship and Home Ownership

Approximately 14% of households indicated poor housing quality (cracks in walls/floors/windows, broken plumbing, or exposed wires) [Table 1]. Approximately 7% of units met criteria for crowding, about a third of households indicated a lack of amenities (33%), and around 5% of households did not have access to a vehicle. Over half (66%) of heads of household indicated that they owned rather than rented the home. Units that were rented rather than owned were more likely to be of poor quality (17% versus 12%,  $P<0.001$ ). Non-Hispanic Black and Hispanic households were much less likely to own units in comparison to non-Hispanic Whites (44% and 47% versus 77%,  $P<0.001$ ).

### Frequency of Asthma by Selected Household Characteristics

Frequency of asthma diagnosis differed significantly by racial/ethnic group ( $P<0.001$ ). Asthma diagnosis in children was most common in households with income at or below the poverty level and when the head of household was non-Hispanic Black, had less education, or was female [Table 2]. Households with poor quality housing, crowding, lack of amenities, or no vehicle access all had higher rates of asthma in children. Asthma was less frequently

diagnosed in homes that were owned by the head of household rather than rented (18% versus 24%).

### **Association of Race/Ethnicity with Asthma Diagnosis and ED Visits**

In unadjusted analyses, non-Hispanic Black households had 70% higher odds of having a child diagnosed with asthma in the home in comparison to non-Hispanic Whites (OR 1.72, 95% CI 1.50-1.96,  $P<0.001$ ) [Table 3]. These households also had 202% higher unadjusted odds of ED visits for asthma (OR 3.02, 95% CI 2.29-3.99,  $P<0.001$ ). Adjusting for household income and education diminished the race/ethnicity-asthma association for both asthma diagnosis and ED visits (“SES/Demographic Adjusted” in Table 3). The race/ethnicity-asthma association further decreased but was not eliminated after adjusting for material hardship measures (poor housing quality, crowding, lack of amenities, no vehicle access) and home ownership (AOR decreased from 1.48 (95%CI 1.29-1.71) to 1.41 (95% CI 1.21-1.62) for asthma diagnosis, AOR decreased from 2.28 (95% CI 1.69-3.08) to 2.07 (95%CI 1.50-2.86) for ED visits). In unadjusted analyses, there was no association between Hispanic ethnicity and asthma diagnosis in comparison to white households, although Hispanic ethnicity was associated with a higher unadjusted odds of ED visits for asthma (OR 1.75, 95% CI 1.26-2.44,  $P=0.001$ ). However, after adjusting for SES/demographic, hardship, and home ownership, Hispanic households had lower odds of asthma diagnosis in children. Asian households had lower odds of asthma diagnosis than White households.

### **Association of Material Hardship Measures with Asthma Diagnosis and ED Visits**

In unadjusted analyses, we found that households with poor housing quality had a higher odds of asthma diagnosis (OR 1.61, 95% CI 1.42-1.82,  $P<0.001$ ) and ED visits (OR 1.95, 95% CI 1.48-2.56,  $P<0.001$ ) [Table 4]. Crowding, lack of amenities, and no vehicle access were all associated with higher rates of asthma and asthma-related ED visits in unadjusted analysis. Poor housing quality remained strongly associated with asthma diagnosis and ED visits after adjusting for both measures of SES, race/ethnicity, and demographic factors (“SES/Demographic Adjusted” in Table 4) as well as when other material hardship markers and home ownership were included in analysis (Model 1 in Table 4). The relationship between poor housing quality and asthma also remained significant after adjustment for household exposures (cigarette smoke, mold, mice, and cockroach) (Model 2 in Table 4). In the fully adjusted model (Model 2), housing crowding, lack of amenities, and no vehicle access showed no statistically significant association with asthma diagnosis or ED visits.

### **Association of Home Ownership with Asthma Diagnosis and ED Visits**

We found that home ownership was negatively correlated with asthma diagnosis and ED visits for asthma. Even after adjusting for head of household race/ethnicity, income, education, hardship measures, and home ownership, as well as potentially mediating household exposures, households that were owned by someone living in the home had a 13% lower odds of having a child in the home with asthma, and a 37% lower odds of ED visits for asthma.

## Discussion

In this analysis of a nationally representative dataset, we found that non-Hispanic Black households were much more likely to have children with asthma and asthma-related ED visits than non-Hispanic White households. These racial/ethnic disparities were incompletely explained by the traditional measures of socioeconomic status, income and education. Controlling for broader experiential measures of socioeconomic status, material hardship and home ownership, decreased the observed magnitude of these disparities, but large inequities remained, particularly in ED visits for asthma. Of these broader measures, those related to housing quality and home ownership were strongly and independently associated with asthma diagnosis and ED visits, while those not directly related to housing quality (i.e. crowding, lack of amenities, and no vehicle access) were not independently associated with asthma diagnosis or control. Households with poor quality housing had a 50% higher odds of an asthma-related ED visit in the past year, while home ownership conveyed an almost 40% lower odds of an ED visit, even after adjusting for housing quality and the presences of housing related exposures known to be associated with asthma (household pests, mold, and cigarette smoke exposure). Together, these findings suggest that poor housing quality and lack of home ownership may partially mediate racial/ethnic disparities in asthma outcomes, and support the idea that poor housing quality could be targeted to reduce asthma-related health disparities in children.

Our findings that Hispanic and Asian households had less frequent asthma diagnosis than White households is similar to other national data.<sup>3</sup> Given the magnitude of disparity observed between non-Hispanic Black and White households in asthma diagnosis and ED visits, we have chosen to focus on these populations for the bulk of our discussion.

Many previous studies have found similarly large associations between non-Hispanic Black race, higher rates of pediatric asthma, and worse asthma-related morbidity.<sup>5,25,26</sup> Although genetic explanations have been sought for these dramatic disparities<sup>27,28</sup>, some have suggested that a large portion of these differences may be due to residual confounding from inadequately measured socioeconomic disparities.<sup>6,7,29,30</sup> In other words, inadequately measuring SES leads investigators to overestimate the independent effect of racial/ethnic differences on health.<sup>6,13,31,33</sup> Measuring income alone does not account for stark racial/ethnic inequities in other economic factors (such as home ownership, debt, and retirement savings)<sup>8</sup> that are the result of segregation and other institutionalized forms of racism.<sup>31</sup> We are only aware of one other study that examined how hardship may explain pediatric race-asthma disparities above and beyond traditional SES measures. *Beck et al*<sup>32</sup> found that a large portion of racial/ethnic disparities in the increased rate of hospital readmission for asthma was explained by financial and social hardships (e.g. home ownership, car ownership, ability to borrow money). Our study confirms in a large national dataset that apparent racial/ethnic disparities in both asthma diagnosis and ED visits for asthma are reduced after controlling for financial and social hardships, particularly those related to housing.

To address health disparities, we must identify the mechanisms by which minority families have worse health outcomes and then design targeted interventions that address those

specific issues. Of the material hardship measures examined in our analysis, we found that poor housing quality in particular (defined as cracks in walls/floors/windows, broken plumbing, or exposed wires) was strongly and independently associated with asthma and ED visits for asthma. Our findings related to housing quality are similar to prior studies of smaller datasets.<sup>17,18</sup> Poor quality housing may be causally related to asthma diagnosis and exacerbation, given that aspects of poor quality housing (e.g. cracks in walls/floors/windows and broken plumbing) increase the likelihood that residents are exposed to allergens that have been shown to increase the risk of asthma exacerbation.<sup>33</sup> We found that poor housing quality was associated with asthma diagnosis and ED visits, even after adjusting for some of these exposures (cigarette smoke, mold, mice and cockroach), but our conclusions are limited by the fact that exposures were assessed by self-report. Nonetheless, we emphasize that policy makers should focus on improving housing quality to combat racial/ethnic disparities in pediatric asthma. We have analyzed a nationally representative US Department of Housing and Urban Development (HUD) sponsored data-set. Interventions implemented by HUD in the arenas of low-income housing (section 8, housing vouchers) and housing equity (the Office of Fair Housing and Equal Opportunity) could mitigate the observed disparities. Multiple studies have identified evidence-based interventions for improving asthma outcomes by bettering housing quality.<sup>34</sup>

Another interesting finding from this analysis is that home ownership was strongly associated with decreased rates of asthma diagnosis and ED visits. Prior studies in adults have demonstrated an association between home ownership status and a variety of health outcomes.<sup>16,35</sup> Home ownership may provide a better measure of socioeconomic status than income alone as many Americans use home equity as a primary means of wealth accumulation.<sup>36</sup> However, it is also possible that home ownership is directly related to asthma diagnosis and control by way of differential exposure to poor housing quality and household allergens—home ownership may lead to more control over the physical home environment, decreasing exposure to asthma triggers. Another possibility is that home ownership is a marker for neighborhood factors such as social connectedness and the physical neighborhood environment that may be protective against asthma.<sup>37</sup> Our finding that rented units were more likely to be of poor quality than those that were owned supports this hypothesis. Thus, the striking racial/ethnic inequities that exist in home ownership rates<sup>11</sup> may contribute to disparities in pediatric asthma.

Although our findings are consistent with our hypothesis that hardship measures are associated with poor asthma outcomes, it is also possible that the hardship measures used in this analysis serve as proxy measures for other family characteristics more directly related to asthma outcomes. For instance, parents with more social capital or organizational skills may ensure higher housing quality for their family regardless of poverty level income. These same parents may also have traits that enable them to remember to give medications and make doctor's visits, leading to improved asthma outcomes in their children. Further research will be needed to delineate how much of these observed effects are related directly to housing quality as opposed to other family characteristics that affect asthma outcomes.

There are limitations to consider when interpreting our findings. First, given that this was a secondary analysis, we focused on available variables from the dataset. Our analysis does



not include all relevant measures of interest related to pediatric asthma (e.g., symptoms frequency, asthma control, medication adherence), material hardship, or home ownership. Other factors associated with poverty (such as stress, exposure to violence, and depression) have been linked to asthma morbidity<sup>5</sup>, but were not included in the American Housing Survey. Second, the data were collected at the level of the household rather than individual child and thus we could not account for important child-level variables (e.g., age, gender). Furthermore, ED visit questions only pertained to the youngest child in the home with asthma, potentially missing older children who visited the ED. Although these methodological issues may alter the magnitude of asthma diagnosis estimates, it is reassuring that the race-asthma relationships in this sample are similar to what has been demonstrated previously.<sup>5,25</sup> All data are self-reported by the head of household which may introduce bias including social desirability and recall biases. We did not have access to relevant neighborhood factors (e.g. social connectedness, physical environment) that may have been relevant to this study. Finally, because the data are cross-sectional, we cannot determine causality. These limitations are balanced by the fact that this is a large, nationally representative dataset with extensive housing data and concurrent data about childhood asthma.

## Conclusion

Controlling for measures of socioeconomic status—specifically household income and education—does not eliminate the observed racial/ethnic disparities in pediatric asthma. In this large national dataset, we found that non-Hispanic Black race was associated with markedly higher rates of childhood asthma and asthma-related ED visits, even after adjusting for income and education. Further adjustment for other measures of material hardship, particularly those related to housing, further diminished the observed racial/ethnic disparities in asthma diagnosis and morbidity, although substantial disparities remained. These findings suggest that targeting housing quality among pediatric patients with asthma may reduce racial/ethnic disparities.

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## Abbreviations

<b>AHS</b>	American Housing Survey
<b>ED</b>	emergency department
<b>SES</b>	socioeconomic status
<b>US</b>	United States

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What's New

In this national dataset, material hardship—housing quality and home ownership specifically—is strongly associated with pediatric asthma. Racial disparities reduced after controlling for material hardship. Policy makers could target improving housing quality as a means of reducing asthma disparities.

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**Table 1**

## Selected Characteristics of Study Sample

	<b>Study Sample</b>	
	<b>No.</b>	<b>%<sup>a</sup></b>
<b>Total</b>	33,201	
<b>Asthma</b>		
Child in home diagnosed with asthma	7,004	19.8
Child with ED visit for asthma	790	2.4
<b>Head of Household Race/Ethnicity</b>		
Non-Hispanic White	18,155	54.7
Non-Hispanic Black	5,431	16.4
Asian	2,104	6.3
Hispanic	6,854	20.6
Other	657	2.0
<b>Head of Household Age</b>		
<25 years old	390	1.3
25-29 years old	2,054	6.1
30-34 years old	4,273	13.9
35-44 years old	13,341	39.9
45-54 years old	9,740	28.3
55-64 years old	2,505	7.6
76-74 years old	680	2.2
75 years or older	218	0.7
<b>Head of Household Sex</b>		
Male	16,184	50.3
Female	17,017	49.7
<b>Household Income as a % of Poverty Level</b>		
100% of poverty level	6,770	19.6
101-249% of poverty level	9,868	31.4
250-499% of poverty level	9,645	30.0
500% of poverty level	6,918	19.0
<b>Head of Household Education</b>		
Less than high school	5,172	14.9
High school graduate	7,469	24.6
Some college or other	10,168	31.2
Bachelor's or higher	10,392	29.4
<b>Housing – Quality</b>		
Poor housing quality, Yes <sup>b</sup>	4,472	13.8

	<b>Study Sample</b>	
	<b>No.</b>	<b>%<sup>a</sup></b>
Evidence of roaches in unit, Yes	5,152	14.9
Mice seen in unit recently, Yes	3,650	12.6
Evidence of mold in unit, Yes	1,765	5.1
<b>Housing – Crowding</b>		
People per bedroom, > 2	2,584	7.4
<b>Lack of Amenities</b>		
Unit lacks any of the following: working washing machine, dishwasher, or refrigerator	11,119	33.7
<b>No Vehicle Access</b>		
No vehicle available for household use	1,793	5.1
<b>Home Ownership</b>		
Owns home	20,213	65.7

<sup>a</sup>Weighted estimates

<sup>b</sup>Poor housing quality defined as cracks in walls/floors/windows, broken plumbing, or exposed wires

**Table 2**

Frequency of Asthma by Selected Household Characteristics

	Child in Household Diagnosed with Asthma (n=33,201)		
	% <sup>a</sup>	95%CI	P-Value <sup>b</sup>
<b>Head of Household Race/Ethnicity</b>			
Non-Hispanic White	18.5	17.6-19.4	
Non-Hispanic Black	28.0	25.8-30.3	
Asian	13.9	11.6-16.5	
Hispanic	18.2	16.8-19.8	<0.001
<b>Head of Household Age</b>			
<25 years old	18.8	12.4-27.4	
25-29 years old	21.9	18.9-25.1	
30-34 years old	22.3	20.5-24.3	
35-44 years old	20.1	19.0-21.2	
45-54 years old	18.4	17.2-19.7	
55-64 years old	17.5	15.2-20.2	
76-74 years old	17.9	13.3-23.6	
75 years or older	19.5	10.6-33.0	<0.001
<b>Head of Household Sex</b>			
Male	16.9	16.0-17.8	
Female	22.7	21.6-23.8	<0.001
<b>Household Income as a % of Poverty Level</b>			
100% of poverty level	26.2	24.6-28.0	
101-249% of poverty level	19.7	18.4-21.0	
250-499% of poverty level	17.4	16.3-18.5	
500% of poverty level	17.0	15.5-18.7	<0.001
<b>Head of Household Education</b>			
Less than High School	22.5	20.5-24.7	
High School Graduate	18.9	17.5-20.4	
Some College or Other	21.1	19.8-22.4	
Bachelor's or Higher	17.7	16.6-18.9	<0.001
<b>Housing – Poor Quality<sup>c</sup></b>			
Yes	26.9	24.8-29.1	
No	18.6	17.8-19.4	<0.001
<b>Housing – Crowding (People per Bedroom)</b>			
2	19.5	18.8-20.2	0.02
> 2	22.9	20.2-25.9	

	<b>Child in Household Diagnosed with Asthma (n=33,201)</b>		
	<b>%<sup>a</sup></b>	<b>95%CI</b>	<b>P-Value<sup>b</sup></b>
<b>Amenities - Unit has working washing machine, dishwasher, and refrigerator</b>			
Yes	18.4	17.6-19.3	
No	22.4	21.1-23.7	<0.001
<b>Vehicle Access</b>			
Vehicle available for household use	19.3	18.6-20.0	
No vehicle available for household use	28.5	25.1-32.2	<0.001
<b>Home Ownership</b>			
Owned	17.8	16.9-18.7	
Rented	23.5	22.3-24.8	<0.001

<sup>a</sup>Weighted estimates.

<sup>b</sup>Calculated using chi-squared

<sup>c</sup>Poor housing quality defined as cracks in walls/floors/windows, broken plumbing, or exposed wires



**Table 3**

Association of Race/Ethnicity with Asthma Diagnosis and ED Visits

	Unadjusted		SES/Demographic Adjusted <sup>a</sup>		Hardship/Home Ownership Adjusted (Model 1) <sup>b</sup>	
	OR	95%CI	AOR	95%CI	AOR	95%CI
<b>Asthma Diagnosis</b>						
Race/Ethnicity						
White, non-Hispanic	Ref	---	Ref	---	Ref	---
Black, non-Hispanic	1.72 *	1.50-1.96	1.48 *	1.29-1.71	1.41 *	1.21-1.62
Asian	0.71 *	0.57-0.89	0.72 *	0.57-0.89	0.72 *	0.58-0.90
Hispanic	0.98	0.88-1.10	0.81 *	0.71-0.93	0.80 *	0.70-0.92
<b>Asthma ED Visits</b>						
Race/Ethnicity						
White, non-Hispanic	Ref	---	Ref	---	Ref	---
Black, non-Hispanic	3.02 *	2.29-3.99	2.28 *	1.69-3.08	2.07 *	1.50-2.86
Asian	0.75	0.38-1.53	0.77	0.38-1.57	0.77	0.38-1.58
Hispanic	1.75 *	1.26-2.44	1.30	0.89-1.91	1.26	0.85-1.89

Logistic regression, all analyses are weighted estimates.

\* statistically significant to a level of  $p < 0.05$ .

<sup>a</sup>SES/Demographic Adjusted: Adjusted for census division, metropolitan status, number of children age 6-17 per household, head of household age and sex, household income as a percentage of the poverty level ( $\leq 100\%$ , 101-249%, 250-499%,  $\geq 500\%$ ), and head of household education.

<sup>b</sup>Hardship/Home Ownership Adjusted (Model 1): Adjusted for all variables in SES/Demographic adjusted analysis, additionally adjusted for material hardship measures (poor housing quality, crowding, lack of amenities, no vehicle access) and home ownership.

**Table 4**

Association of Material Hardship/Home Ownership with Asthma Diagnosis and ED Visits

	Unadjusted		SES/Demographic Adjusted <sup>a</sup>		Hardship/Home Ownership Adjusted (Model 1) <sup>b</sup>		Exposure Adjusted (Model 2) <sup>c</sup>	
	OR	95%CI	AOR	95%CI	AOR	95%CI	AOR	95%CI
<b>Asthma Diagnosis</b>								
Material Hardship								
Poor Housing Quality <sup>d</sup>	1.61 *	1.42-1.82	1.46 *	1.28-1.66	1.45 *	1.28-1.66	1.35 *	1.18-1.54
Crowding: > 2 People/Bedroom	1.23 *	1.05-1.44	1.00	0.84-1.19	0.96	0.81-1.14	0.95	0.80-1.12
Lack of Amenities <sup>e</sup>	1.28 *	1.16-1.41	1.11	1.00-1.23	1.04	0.94-1.16	1.02	0.91-1.15
No Vehicle Access	1.67 *	1.39-2.00	1.21	1.00-1.46	1.13	0.93-1.37	1.10	0.90-1.35
Home Ownership								
Unit is Owned	0.70 *	0.64-0.77	0.84 *	0.76-0.94	0.86 *	0.76-0.96	0.87 *	0.78-0.98
<b>Asthma ED Visits</b>								
Material Hardship								
Poor Housing Quality <sup>d</sup>	1.95 *	1.48-2.56	1.59 *	1.21-2.10	1.59 *	1.20-2.10	1.49 *	1.13-1.98
Crowding: > 2 People/Bedroom	1.56 *	1.08-2.26	1.12	0.72-1.73	1.05	0.69-1.61	1.06	0.69-1.63
Lack of Amenities <sup>e</sup>	1.82 *	1.46-2.27	1.11	0.84-1.47	0.98	0.74-1.31	0.98	0.73-1.30
No Vehicle Access	2.52 *	1.76-3.60	1.23	0.81-1.84	1.11	0.73-1.67	1.10	0.72-1.67
Home Ownership								
Unit is Owned	0.40 *	0.31-0.51	0.62 *	0.46-0.82	0.62 *	0.46-0.84	0.63 *	0.46-0.85

Logistic regression, all analyses are weighted estimates.

\* statistically significant to a level of  $p < 0.05$ .

<sup>a</sup>SES/Demographic Adjusted: Each predictor is adjusted for census division, metropolitan status, number of children age 6-17 per household, head of household race/ethnicity, head of household age and sex, household income as a percentage of the poverty level ( $\leq 100\%$ , 101-249%, 250-499%,  $\geq 500\%$ ), and head of household education, but not the other material hardship predictors or home ownership (as applicable).

<sup>b</sup>Hardship/Home Ownership Adjusted (Model 1): Each predictor is adjusted as in SES/Demographic adjusted analysis, and additionally adjusted for all other material hardship markers listed in the table and home ownership (as applicable).

<sup>c</sup>Exposure Adjusted (Model 2): Each predictor is adjusted as in Model 1, and additionally for exposure to cigarette smoke, mold, mice and cockroach.

<sup>d</sup>Poor housing quality defined as cracks in walls/floors/windows, broken plumbing, or exposed wires.

<sup>e</sup>Lack of amenities defined as unit lacks any of the following: working washing machine, dishwasher, or refrigerator.