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Racial/Ethnic Differences in Asthma Prevalence: The Role of Housing and Neighborhood Environments*

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This article examines the prevalence of asthma among New York City households from 10 racial/ethnic groups, and it explores whether differential exposure to potentially adverse housing and neighborhood conditions helps to mediate observed disparities. After adjusting for household size, Puerto Rican households exhibit the highest levels of asthma, followed by other Hispanic and black households. Mexican, Chinese, and Asian Indian households exhibit the lowest levels of asthma. Results from multilevel logistic regression models indicate that exposure to deteriorated housing conditions and perceptions of low social cohesion in the neighborhood significantly elevate the odds of asthma. Controlling for these conditions along with household characteristics reduces the disproportionately high levels of asthma among Puerto Rican and black households, although they remain significantly higher than the level among white households.

Asthma has been steadily increasing in prevalence since 1980 (Institute of Medicine 2000; Rhodes et al. 2003), and its greater prevalence among low-income and urban residents has caused it to be termed "the other inner-city health crisis" (relative to HIV/AIDS; Boardman, Finch, and Hummer 2001). The concentration of higher-than-average asthma rates among poor, generally minority, inner-city residents, moreover, has been thought to be linked to the low quality of housing such groups occupy, as well as the concentration of outdoor pollutants in their neighborhoods (Katz, Kling, and Liebman 2001). Yet, largely because of a lack of data sets combining health indicators and housing quality at the individual level and aspects of conditions prevailing at the neighborhood level, there has been little work done to date that explicitly evaluates the role played by housing and neighborhood conditions in mediating observed disparities in asthma. This article helps to address this gap in the literature, by estimating multilevel models predicting asthma prevalence among New York City households as a function of housing conditions and features of the surrounding area.

DIFFERENTIALS IN AND CORRELATES OF ASTHMA

Rates of self-reported asthma vary across racial/ethnic groups. In 2001, among persons reporting a single race, non-Hispanic blacks were most likely to report having asthma (with 8.5 percent of respondents reporting that they currently suffer from the condition), followed by non-Hispanic whites (at 7.2 percent), other race non-Hispanics, and finally Hispanics (both at 5.9 percent) (Rhodes et al. 2003). While the black/white differential has been consistently reported in other sources, including national data sets, there are indications that the prevalence of asthma also varies across individual Hispanic origin groups (Kinnert et al. 2002). For example, data from the Hispanic Health and Nutrition Survey (HHANES) indi-

cate that Puerto Rican children are more likely to have asthma than their Cuban American and Mexican American counterparts (Mendoza et al. 1991). The higher prevalence of asthma among Puerto Ricans is consistent with the finding that the prevalence of lifetime asthma in 2001 was highest in Puerto Rico relative to the other 53 reporting areas of the Behavioral Risk Factor Surveillance System (BRFSS) (Rhodes et al. 2003). Unfortunately, little is known about the prevalence of asthma among Asians, nor among specific Asian origin groups (Boardman et al. 2001).

Several risk factors for asthma have been identified. Exposure to tobacco smoke in the home raises the risk of asthma, as does low socioeconomic status and metropolitan residence (Institute of Medicine 2000; Miller 2000; Shaw 2004). Researchers have suggested that at least part of the effect of socioeconomic status is accounted for by the fact that economically disadvantaged families are more likely to occupy inadequate housing (Boardman et al. 2001), and thus experience greater exposure than do more affluent families to the kinds of asthma triggers—including dust mites, pet dander, cockroach and mice feces, and mold—that are found in substandard housing (Bashir 2002; Kreiger and Higgins 2002; Rauh, Chew, and Garfinkel 2002). Moreover, the finding that metropolitan residence significantly predicts asthma among black but not white children has been argued to reflect the segregation of many black children in deteriorated inner-city neighborhoods (Boardman et al. 2001) that are home also to many sources of outdoor pollutants, including transfer stations, industrial land uses, and transportation depots (Gold and Wright 2005). Such logic can be extended to account for the high incidence of asthma among Puerto Ricans, who experience many of the same disadvantaged housing and neighborhood environments (Rosenbaum 1996; Rosenbaum et al. 1999). Persuasive evidence of the influence of housing and neighborhood conditions on asthma comes from the Moving to Opportunity Demonstration Program Boston site, where children who moved from public housing in high-poverty neighborhoods to higher-quality housing in other neighborhoods experienced a 50 percent drop in asthma attacks (Katz et al. 2001).

RACIAL/ETHNIC DISPARITIES IN HOUSING AND NEIGHBORHOOD CONDITIONS

A long literature has documented the persistence of racial/ethnic disparities in housing and neighborhood conditions, net of socioeconomic status, that work to the disadvantage of African Americans, Puerto Ricans, and nonwhite Hispanics more generally. In terms of housing, blacks and Hispanics in New York City are more likely than whites and Asians to occupy housing units that suffer from numerous structural and maintenance deficiencies, such as interior and exterior leaks, chipping paint and broken plaster, holes in the floors or walls, and pest infestation (Rosenbaum and Friedman 2007). These housing conditions also appear to be more common among Puerto Ricans and Dominicans than among Central or South Americans, and are more prevalent among Hispanics reporting black than non-black race (Rosenbaum and Friedman 2007). The disproportionate exposure to substandard housing experienced by blacks and Hispanics also holds on a national level, regardless of whether the household owns or rents its unit (Friedman and Rosenbaum 2004). The kinds of housing problems documented for blacks and Hispanics, moreover, are precisely those that can give rise to asthma attacks (Bashir 2002; Krieger and Higgins 2002; Rauh et al. 2002).

With respect to neighborhood conditions, it has long been recognized that the housing stock and the neighborhood amenities found in minority neighborhoods are of lower quality than those found in areas where whites predominate (Massey, Condran, and Denton 1987; Massey and Denton 1993). Studies of the locational attainment process have demonstrated a general pattern of access to advantaged areas whereby whites experience the highest levels of access, followed by Asians, Hispanics, and finally blacks (Alba and Logan 1991, 1993). These patterns also hold in New York City, where blacks and Hispanics are more likely than whites to live in neighborhoods with boarded-up buildings, and high crime and poverty rates, and where residence in disadvantaged neighborhood environments is more prevalent among Puerto Ricans and Hispanics reporting black race relative to non-Puerto Ricans and non-black Hispanics (Rosenbaum and Friedman 2007). The fact that racial/ethnic differentials in housing and neighborhood conditions persist in the face of controls for so-

cioeconomic status and other individual-level predictors suggests that the disadvantages experienced by Hispanics and, especially, blacks are largely the result of housing market discrimination (Turner et al. 2002; Yinger 1995).

THE MECHANISMS LINKING HOUSING AND NEIGHBORHOOD ENVIRONMENTS TO ASTHMA

Researchers have identified three potential pathways leading from environmental context to asthma: differential exposure, stress, and health-related behaviors (Gold and Wright 2005). For those environmental conditions recognized as asthma triggers—such as dampness, dust mites, cockroach and rodent feces within the home, and excessive levels of pollutants outdoors—direct exposure is the most likely mechanism linking physical context and asthma. The housing market forces that limit the choices of blacks, Puerto Ricans, and non-white Hispanics generally to badly maintained housing and disadvantaged neighborhoods, therefore, disproportionately expose these groups to a variety of asthma triggers. Controlling for this differential exposure may thus help to mediate observed differentials in asthma prevalence.

While exposure to indoor and outdoor pollutants reflects a direct relationship between environmental context and asthma, stress and health-related behaviors act as intervening variables linking context and asthma. These indirect pathways reflect a process whereby the environmental context increases the individual's *vulnerability* to asthma, which then in turn raises the likelihood of acquiring the condition. For example, when confronted with a stressful situation, the body releases a number of hormones that enhance the chance of surviving or overcoming the immediate, short-term threat (the "fight or flight" response). Yet when stressful situations become chronic, these hormones overload the system and erode the effectiveness of the immune system, thereby increasing the individual's vulnerability to illness (Hill, Ross, and Angel 2005; Massey 2004). Living in neighborhoods characterized by high levels of physical and social disorder has been identified as a chronic stressor, since residents are constantly aware of the dangers surrounding their homes (Downey and van Willigen 2005; Wright et al. 2004). While residence near industrial activity may expose residents to asthma triggers, it can also increase vulnera-

bility to asthma onset by heightening stress levels (Downey and van Willigen 2005).

Living in disadvantaged neighborhoods also increases residents' vulnerability to ill health by affecting their behaviors. The fear and stress associated with neighborhood crime and violence may increase peoples' tendency to smoke (Gold and Wright 2005; Wright et al. 2004). By causing people to fear for their safety, neighborhood crime and disorder may also cause residents to spend more time indoors (Cagney and Browning 2004, 2005), and parents to exercise "protective parenting" (Furstenberg et al. 1999), thereby increasing their exposure to the asthma triggers inside their homes. Because the forces that create and maintain high levels of racial/ethnic segregation also concentrate poverty and its associated problems (including crime and disorder) in minority neighborhoods (Massey and Denton 1993), residents of such areas have a disproportionately higher vulnerability to disease as a result of heightened stress and potentially health-damaging behaviors (Massey 2004).

HYPOTHESES

In summary, substantial evidence demonstrates that blacks and particular Hispanic subgroups are disproportionately likely to experience substandard housing and neighborhood environments. Such differentials parallel those in asthma prevalence, suggesting that direct exposure to substandard housing and neighborhood conditions, and the increased vulnerability to ill health associated with these conditions, may contribute to the observed variation in asthma rates. I therefore expect that residence in badly maintained and crowded housing, and in areas with higher levels of manufacturing activity and greater concentrations of transportation facilities, will be associated with higher levels of asthma prevalence, largely because of the concomitant higher degree of exposure to asthma triggers. Living in highly segregated areas and those with high crime rates, and perceiving a low level of social cohesion in one's neighborhood will also be positively associated with the prevalence of asthma, but these two forces will more likely operate through the indirect routes of higher stress and negative health-related behaviors. Finally, and most importantly, I expect that controlling for these aspects of the environmental context will mediate the observed racial/ethnic disparities in asthma, and thus

cause the observed disparities to lessen in size or disappear altogether. Should this last hypothesis be supported, then housing market discrimination—the presumed root of housing and neighborhood inequalities—can be considered as a contributing cause of such disparities (cf. Cain and Kington 2003) and a key mechanism by which race/ethnicity is a "fundamental cause" of disease (Link and Phelan 1995).

DATA AND METHODS

Data

The primary source of data is the 2002 panel of the New York City Housing and Vacancy Survey (HVS), a multistage probability sample of approximately 16,000 occupied housing units located throughout the five counties, or boroughs, which make up the city. The HVS is conducted every two or three years by the Census Bureau under contract to the City of New York, in compliance with state and local laws regarding rent control. The 2002 panel is based on a sample drawn from the 2000 Census address list. As an inter-censal survey containing a wealth of information, the HVS is the best source of up-to-date information concerning the city's population and its housing. After eliminating cases with missing data on the dependent and independent variables, the analytical data set contains 12,058 households.[1]

A number of new questions were added to the 2002 panel that extends the HVS's reach into the sphere of health. Of importance here is a question that asked whether there is anyone in the household who has been told by a doctor or other health professional that she or he has asthma. This question likely underestimates differences in the prevalence of asthma, given that findings from a census of 1,982 children under 16 in Central Harlem conducted by the Harlem Children's Zone Asthma Initiative revealed a level of asthma more than *four times higher* than the national level of childhood asthma: Fully 30.2 percent of the children assessed were either diagnosed with asthma or exhibited asthma-related symptoms, including many who had never received a formal diagnosis of asthma (Nicholas et al. 2005). This first question was followed up with the interviewer asking how many such people live in the household. As a result, the specific individuals with asthma are not identified, and thus it is unclear if those persons are children, adults, or both. Because almost 85 percent of households

report no asthmatics, the dependent variable in the analysis is a dichotomy that is coded 1 when there is at least one asthmatic present in the household and 0 when no asthmatic is present.

The analysis focuses on three key sets of independent variables: race/ethnicity, housing conditions, and neighborhood conditions. Ten categories of (self-reported) race/ethnicity are used: non-Hispanic white, non-Hispanic black, Puerto Rican, Dominican, Central/South American, Mexican, other Hispanic, Chinese, Asian Indian, and other Asian. I omit from the analysis the very few non-Hispanic households headed by someone reporting more than one race (0.5 percent of all households). In the multivariate analysis, non-Hispanic whites are used as the reference group.

With respect to housing conditions, four indicators are used. The first is the number of maintenance deficiencies in the housing unit, which is a summary index of seven possible deficiencies reported by the respondent for the three months preceding the survey. These deficiencies are: toilet breakdowns; heating breakdowns; the need for additional heat; the presence of rats or mice; leaks from the outside; cracks or holes in the floors, walls, or ceiling; and large areas of broken plaster. Three dichotomous variables (coded 1 if the condition is present, 0 otherwise) are used to differentiate housing units with no deficiencies (the reference category) from those with only one or two, or three or more, of these deficiencies.

The second indicator of housing conditions is crowding (coded 1 if there is at least one person per room, and 0 otherwise), and the third is tenure status (coded 1 for renters, 0 for owners). Crowding is important to examine since it has been associated with poorer physical and mental health (Edwards et al. 1994; Gove, Hughes, and Galle 1979), and with elevated levels of cockroach allergens (Leaderer et al. 2002). As an indicator of substandard housing conditions, crowding is expected to be positively associated with the prevalence of asthma. Renter households are expected to exhibit a higher prevalence of asthma than are owner households, in part because of the generally lower quality of rental housing and the lower socioeconomic profile of renters versus owners. The final housing condition is a dichotomy differentiating between households in which at least one smoker is present from those free of resident smokers. Because indoor tobacco

smoke can trigger asthma onset and asthma attacks, exposure to smokers in the home should be positively associated with asthma prevalence.

A total of six indicators of neighborhood conditions are used. Two are measured at the individual level but reflect conditions in the broader area. The first of these, a dichotomy indicating whether there are any boarded-up buildings within 300 feet of the sampled housing unit, derives from an interviewer observation. While the presence of boarded-up buildings and the physical decay they signal may reflect the presence of asthma triggers, they also indicate social disorder, and thus may make area residents more vulnerable to disease by heightening their stress levels or altering their behaviors.

The second measure taps into the amount of social cohesion in the neighborhood, as perceived by the respondent. This variable derives from the mean score on responses (strongly agree to strongly disagree, coded 1 to 4) from two items often used in scales measuring social cohesion: "People in this neighborhood can be trusted" and "People in this neighborhood are willing to help their neighbors." The variable used in the analysis is a dichotomy, coded 1 for households reporting little or no social cohesion (those with a mean score of 2.5 or above on the two items) and 0 otherwise. Although a measure obtained for the aggregate level would have been preferable as an indicator of limited social cohesion, the householder's perception will directly shape his or her own behavior and family management techniques. As a result, this perception may serve as a proxy for feelings of stress deriving from living in a threatening environment. Like the presence of boarded-up buildings, then, the perceived lack of social cohesion will also be positively associated with asthma prevalence by increasing vulnerability.

The final four indicators of neighborhood conditions are measured for the 55 subareas identified in the HVS. The HVS subareas are geographic units comprised of entire Census tracts with a minimum population of 100,000 in accordance with Census Bureau rules on confidentiality. Although larger than what most researchers consider "neighborhoods," subareas are very similar to the 59 community districts in New York, and thus are meaningful geographic units for service delivery and policy making. I used *Infoshare* to create the sub-

area indicators. *Infoshare* is a unique data base containing public and private sources of data for New York that allows users to aggregate data up to a specified number of geographies, including the HVS subarea.

The first subarea measure, the percent white, derives from 2000 Census data. Percent white is used to control for the high degree of racial/ethnic segregation in New York City and was chosen over percent black because of the emergence of large swaths of predominantly non-white areas composed almost exclusively of blacks and Hispanics (Alba et al. 1995; Lobo, Flores, and Salvo 2002). The second subarea measure, the 2000 violent crime rate (measured per 1,000 population), uses the number of violent crimes against individuals (i.e., murder, rape, assault, robbery) originally reported by the New York City Police Department. Because segregation concentrates poverty and its correlates in predominantly minority neighborhoods, residents of such areas experience higher levels of chronic stress and are thus more vulnerable to disease than are residents in "whiter" neighborhoods (Massey 2004). Similarly, residence in violent and dangerous neighborhoods increases stress levels and may alter residents' behaviors, thereby heightening residents' vulnerability (Wright et al. 2004). As a result, the prevalence of household-level asthma should rise along with the crime rate but fall as percent white rises.

The final two subarea conditions are hypothesized to influence asthma prevalence through the mechanism of exposure. These measures derive originally from data from the New York City Department of Finance on land use (for 1999). The first is the number of transportation facilities (such as bus maintenance depots, train yards, and ferry terminals) per 100,000 population, and the second is the number of light and heavy manufacturing facilities per 100,000 (both use 2000 Census counts in the denominator). The concentration of transportation facilities in an area will give rise to high levels of pollutants from idling buses and trucks, and heavy vehicular traffic more generally. Exposure to mobile sources of pollutants such as these may have more profound consequences for residents' health than stationary sources (Morello-Frosch 2006), such as the output stemming from manufacturing activities. Therefore, I expect that residence in areas with high concentrations of either type of ac-

tivity—manufacturing or transportation uses—will be associated with higher levels of asthma.

The remaining independent variables include indicators of household composition and socioeconomic status (age of householder, educational attainment of householder, householder gender, total household income/10,000, and household receipt of Temporary Assistance to Needy Families [TANF]) that affect where people live. I use these household characteristics mainly as statistical controls. I also use controls for the number of children ages 0 through 12 and the presence of teenagers (children ages 13 through 17) to account for group differences in household size. This is essential given that the particular asthmatic is not identified by the dependent variable, and because the risk of having an asthmatic in the household is directly affected by the size and age composition of the household.[2] Additional controls include nativity status of the householder (coded 1 for foreign-born householders and householders born on the island of Puerto Rico,[3] 0 otherwise), given the importance of immigration in New York City and the likelihood of a "healthy immigrant" effect (cf. Kinnert et al. 2002). The final control variable is a measure of the length of time households have occupied their housing units. This last variable is a dichotomy coded 1 for households who have lived in their units for five or more years, and 0 otherwise. Controlling for duration in place is essential for mitigating some of the limitations of cross-sectional data for this type of analysis.

Methods

The clustering of households within subareas suggests the need for multi-level modeling techniques. This need is validated by the intraclass correlation coefficient (ICC) for subareas (level 2) calculated from the null model, which indicates that subareas account for about 16 percent of the variation in household-level asthma. As a result, the model is estimated using multilevel logistic regression techniques available in the SAS procedure, "proc glimmix."

RESULTS

Descriptive Analysis

Table 1 shows two sets of percentages: the "raw" percentage of households with at least one asthmatic (by race/ethnicity), calculated directly from the data, and the "adjusted" per-

centages, which have been standardized by applying the distribution of white households by number of children ages 0 through 17 to the household-size-specific asthma rates exhibited by each nonwhite group. The adjusted percentages are therefore free of much of the distortion arising from group differences in household size, and thus improve the validity of cross-group comparisons.

Regardless of the measure used, the data reveal a huge range in the experience of asthma. Focusing on the adjusted percentages, Puerto Rican households are the most likely to contain at least one asthmatic, and they are more than 2.5 times more likely to do so compared to white households. All other Hispanic households report lower levels of asthma relative to Puerto Rican households, a finding consistent with those of other studies (Kinnert et al. 2002; Mendoza et al. 1991). The low level of adjusted asthma prevalence among Mexican households—less than half that among white households and less than one-fifth that among Puerto Rican households—suggests additional evidence of the "epidemiological paradox" characterizing this group, namely, fairly robust health conditions in the face of low socioeconomic status (Boardman et al. 2001; Kinnert et al. 2002). Black households are also more likely to contain an asthmatic than are white households, while Chinese and Asian Indian households are less likely to do so.

TABLE 1. **Percent of New York City Households That Contain at Least One Asthmatic, by Race/Ethnicity of Householder, 2002**

Race/Ethnicity of Householder	Raw Percent	Adjusted Percent[a]
Non-Hispanic white	11.07	
Non-Hispanic black	18.88	15.82
Puerto Rican	32.85	28.02
Dominican	17.78	14.78
Central/South American	16.04	13.28
Mexican	10.47	5.05
Other Hispanic[b]	17.52	16.83
Chinese	7.83	6.81
Asian Indian	9.02	7.32
Other Asian[c]	12.46	11.72

[a] The distribution of the number of children younger than 18 in the household for whites is used to adjust the percentages.
[b] Category includes Cubans and "other" Hispanics.
[c] Category includes Koreans, Japanese, Filipinos, Vietnamese, other Pacific Islanders, and "other" Asians.

To what degree is the variation in asthma prevalence associated with differential exposure to potentially adverse housing and neighborhood conditions? To lend insight to this question, Table 2 presents descriptive statistics for the housing, neighborhood, and subarea conditions for each racial/ethnic group (household characteristics can be found in the Appendix). Starting with the housing characteristics, crowding is most extreme among Mexican, Dominican, Central/South American, and Asian Indian households, a finding undoubtedly related to the fact that the vast majority of these households are headed by immigrants (Appendix). The presence of smokers in the household is highest among Puerto Ricans, other Asians, and other Hispanics, while all Hispanic (apart from Central/South American) and black households are most likely to live in units plagued by three or more maintenance deficiencies. Finally, white and Chinese households are least likely to be renters, while home ownership is extremely rare among Mexican and Dominican households.

Turning to the neighborhood characteristics, Puerto Ricans are most likely to report little or no social cohesion in their neighborhoods, with just over 30 percent doing so, followed by Central/South Americans, African Americans, and Dominicans, at about 24 percent. African Americans are most likely to live near boarded-up buildings (16 percent), followed by Mexicans and Puerto Ricans (14 and 11 percent, respectively). In contrast, whites live in neighborhoods with the highest levels of social cohesion (as reported by the respondent), and along with all Asian and Central/South American households, they also live in neighborhoods with the fewest signs of physical decay.

Given the persistence of extremely high levels of white/black segregation in New York City (Rosenbaum and Argeros 2005), it is hardly surprising that the mean percentage of whites in the subarea is lowest among black households. Puerto Rican and Dominican households also tend to live in subareas with far fewer white residents relative to the subareas in which whites, Asians, and the remaining Latino groups reside. Somewhat unexpectedly, white households live in subareas with the highest average exposure to transportation facilities, followed by Chinese, Puerto Rican, and Mexican households. In contrast, Central/South Americans experience the highest average exposure to manufacturing facilities at the

TABLE 2. Selected Descriptive Characteristics of New York City Households, by Race/Ethnicity of Householder, 2002 (percentages)

	White	Black	Puerto Rican	Dominican	Cent./S. American	Mexican	Other Hispanic	Chinese	Asian Indian	Other Asian
Housing characteristics										
Crowded	17.52	23.95	24.61	40.42	43.31	74.90	22.29	37.32	47.15	36.29
At least one smoker	23.68	24.61	32.49	13.15	17.42	17.86	29.10	21.12	17.29	29.33
Number of maintenance deficiencies										
None	63.72	44.47	41.65	35.44	49.39	37.80	52.42	63.88	54.02	61.18
One or two	29.73	36.70	38.50	42.57	36.51	42.13	34.16	28.03	36.05	29.03
Three or more	6.55	18.83	19.86	22.49	14.10	20.06	13.42	8.08	9.93	9.79
Renter	56.16	69.96	84.72	92.62	79.29	97.41	71.98	55.45	64.73	68.83
Neighborhood characteristics										
Little/no social cohesion	7.44	23.76	30.49	23.38	24.34	18.99	21.23	14.85	12.51	13.43
Boarded-up buildings nearby	4.00	16.00	11.00	9.00	6.00	14.00	9.00	3.00	2.00	7.00
Subarea characteristics										
Percent white (mean)	63.75	24.09	35.43	31.43	42.24	43.01	47.31	53.75	47.13	51.14
Transportation facilities/100,000 (mean)	570.33	221.57	405.79	279.22	294.00	403.81	337.98	473.63	243.65	339.70
Manufacturing facilities/100,000 (mean)	31.09	31.07	51.07	38.94	60.32	55.59	42.64	34.29	47.38	56.58
Crime rate (mean)	9.17	9.57	11.00	9.97	10.25	11.16	9.47	10.08	8.83	10.12
N of cases	5,238	2,863	1,130	665	615	149	236	429	344	388

subarea level, followed by Dominican, Mexican, and Puerto Rican households. Finally, the subareas in which Mexican and Puerto Rican households live exhibit the highest average violent crime rates.

In summary, the descriptive analysis indicates preliminary support for the notion that housing and neighborhood conditions may mediate racial/ethnic disparities in asthma prevalence, in that the groups most afflicted by asthma tend to live in less-desirable circumstances than do the groups least affected by the illness. This is particularly the case for Puerto Ricans, who exhibit the most extreme levels of asthma while often living in the worst housing and in neighborhoods where exposure to environmental triggers is high, and where social disorder and crime may induce chronically high stress levels or behaviors with the potential to harm one's health. However, to fully determine the extent to which housing and neighborhood conditions account for observed racial/ethnic variation in asthma, we must turn to multivariate analysis.

Multivariate Analysis

Table 3 presents the results of three multi-level logistic regression models (with random intercepts and fixed slopes). Model I includes the racial/ethnic dummy variables along with the indicators pertaining to the number/presence of children of different ages. This model provides significance tests for the adjusted percentages shown in Table 1, and establishes a baseline against which the effects of race/ethnicity in the full models can be compared. The results indicate that black, Puerto Rican, Dominican, and other Hispanic households are all significantly more likely than white households to contain at least one asthmatic, net of the controls for household size and age composition. Similarly, the lower prevalence of asthma among Chinese and Asian Indian households in Table 1 attains significance, while that among Mexican households does not.

Model II, the first full model, uses the summary index of maintenance deficiencies described above. Looking first at the results for the household characteristics, we see clear support for expectations of a "healthy immigrant" effect; the odds of asthma are about 31 percent lower in immigrant than native-born households. Female headship, however, significantly raises the odds of asthma. This variable is prob-

ably a better indicator (relative to the other householder characteristics) of the socioeconomic status of all members of the household, and thus likely reflects the negative association of asthma with socioeconomic status at the individual level, as reported by others (e.g., Boardman et al. 2001; Miller 2001). As expected, the odds of having at least one asthmatic present in the household significantly rise with the number of children and teens in the household.

The results for the housing, neighborhood, and subarea characteristics reveal solid support for hypotheses concerning the potentially adverse effects of deteriorated housing and threatening neighborhoods. With respect to housing conditions, the odds of asthma rise substantially along with the number of maintenance deficiencies, suggesting that direct exposure to higher concentrations of asthma triggers escalates household members' risk for the condition. This effect is quite substantial; relative to living in a unit that is free of any type of maintenance deficiencies, living in a unit with one or two problems raises the odds of asthma by just over 44 percent, while living in a more deteriorated unit *almost doubles* the odds of asthma. With respect to the neighborhood and subarea effects, perceiving little or no social cohesion in one's neighborhood significantly raises the odds of asthma by almost 17 percent, and living in subareas with higher concentrations of transportation facilities also bears a positive and significant relationship to the odds of asthma among household members. This latter effect, however, is quite small.

Model III replicates Model II but replaces the summary index of maintenance deficiencies with dichotomies indicating the presence (during the three months preceding the survey) of each of the seven conditions used to create the index. The purpose of this substitution is to evaluate if *all* or only a subset of the measured conditions significantly predict the prevalence of asthma. As would be expected, the results for the other variables in the basic full model remain largely unchanged by this substitution. Four of the seven conditions significantly raise the odds of asthma in the household. For example, households living in units that experienced heating breakdowns or needed additional heat in the preceding three months are about 19 and 18 percent, respectively, more likely to contain an asthmatic than those without heating problems. Similarly, the odds of house-

TABLE 3. Results of Multilevel Logistic Regression Models Predicting the Prevalence of Asthma in New York City Households, 2002 (odds ratios; N = 12,058)

Predictors (Level I)	Model I	Model II	Model III
Race/ethnicity (vs. white)			
Black	1.574***	1.329**	1.329**
Puerto Rican	3.369***	2.894***	2.909***
Dominican	1.301*	1.332*	1.326*
Central/South American	1.187	1.342*	1.342*
Mexican	.681	.836	.862
Other Hispanic	1.616**	1.783**	1.762**
Chinese	.586**	.749	.751
Asian Indian	.583**	.803	.809
Other Asian	1.032	1.222	1.225
Household characteristics			
Foreign-born householder[a]		.707***	.701***
Householder age		1.002	1.002
Householder education (vs. some college or more)			
Less than high school		.979	.978
High school diploma		.939	.936
Female householder		1.261***	1.269***
Number of children 0–12 (vs. none)			
One	1.667***	1.649***	1.661***
Two or more	2.345***	2.363***	2.344***
Presence of children 13–17	1.659***	1.632***	1.625***
Household income/10,000		1.006	1.006
Receives TANF		1.321	1.292
Lived in unit 5+ years		1.090	1.088
Housing characteristics			
Crowded		.996	.986
At least one smoker		1.119	1.115
Number of maintenance deficiencies (vs. none)			
One or two		1.442***	
Three or more		1.931***	
Type of maintenance deficiency			
Toilet breakdowns			1.087
Heating breakdowns			1.185*
Need additional heat			1.178*
Presence of mice or rats			1.254***
Cracks/holes in walls, floors, ceiling			1.142
Large patches of missing plaster			.917
Leaks (from inside)			1.343***
Renter		.979	.979
Neighborhood characteristics			
Little/no social cohesion		1.169*	1.160*
Boarded-up buildings nearby		1.064	1.046
Predictors (Level II)			
Subarea characteristics			
Percent white		.998	.998
Transportation facilities/100,000		1.000*	1.000*
Manufacturing facilities/100,000		1.000	1.000
Crime rate		1.003	1.004
Intercept	2.142***	.073***	.076***
–2 log likelihood	9817.9***	60771.5***	60740.4***
d.f.	12	31	36

* $p \leq .05$; ** $p \leq .01$; *** $p \leq .001$
Note: TANF = Temporary Assistance for Needy Families.
[a] Includes householders born on the island of Puerto Rico.

hold-level asthma are more than 25 percent higher when housing units are infested with rodents, and they are more than 35 percent higher when housing units experience leaks from the outside, relative to when the housing is free of rodents and is watertight. These results, then, are consistent with prior reports of the influence of dampness, lack of heat, and rodent infestation on the risk of asthma (Bashir 2002; Kreiger and Higgins 2002; Rauh et al. 2002;

Shaw 2004). Yet not only do these conditions *individually* increase the risk of asthma, but when found *together* (as shown in Model II), the risk of asthma is greatly magnified.

As theorized earlier, the deleterious consequences of perceiving a lack of social cohesion among one's neighbors may reflect heightened stress or the use of defensive behaviors, such as remaining indoors, which may exacerbate exposure to indoor triggers. To test this hypothesis, two additional models were estimated (results available upon request). The first includes fixed interactions between low perceived social cohesion and the presence of smokers, and between social cohesion and the number of maintenance deficiencies. The second model replaces the latter interactions with terms interacting low perceived social control with each of the four significant individual maintenance conditions (heating breakdown, need for additional heat, presence of rodents, and leaks from the outside). No interactions in the first model emerged as significant, and in the second model there was only one (social cohesion x leaks from the outside, *p* < .05). This interaction, though, was *negative* in direction, suggesting that perceptions of limited trust and safety among one's neighbors moderates the higher risk for asthma associated with this aspect of substandard housing. This result suggests that perceiving limited support and potential dangers in the surrounding neighborhood may impact asthma by increasing stress, rather than by compounding exposure to asthma triggers. Such an interpretation is consistent with the finding that stress mediates some of the effect of community violence on residents' asthma (Wright et al. 2004).

Finally, controlling for the full range of variables reduces the extent of excess asthma morbidity among black and Puerto Rican households by 43 and 20 percent, respectively. This finding suggests that at least part of the excess morbidity experienced by black and Puerto Rican households in New York City is accounted for by the racial/ethnic disparities in housing and environmental conditions that work to the disadvantage of these groups. Additional models that enter each block of variables along with the race/ethnicity dichotomies (available upon request) indicate that the sets of housing, neighborhood, and subarea characteristics individually act to mediate the disproportionately high levels of asthma among blacks and Puerto Ricans, with the set of housing conditions having the greatest mediating effect.

While controlling for the full range of predictors lessens the extent of excess asthma morbidity among two of the most badly affected groups, the same is not true for other groups. Specifically, the higher odds of asthma among Dominican and other Hispanic households evident in Model I remain significant and increase slightly in size in both full models, while the effect associated with Central/South American households becomes both larger and statistically significant. Similarly, controlling for the full set of predictors eliminates the statistically significant advantage in asthma prevalence among Chinese and Asian Indian households, and this also brings the odds of asthma among these groups closer to those exhibited by whites. Additional analyses suggest that these effects result from the beneficial influence of foreign birth. Once the advantage of being an immigrant household is removed, the odds of having at least one asthmatic in the household rises for those groups with a high representation of the foreign born.

In summary, the analysis demonstrates that neighborhood and especially housing characteristics exhibit expected relationships with the prevalence of asthma at the household level. In general, households living in deteriorated housing units—especially those that are damp, infested with rodents, and lacking sufficient heat—and who perceive little or no social cohesion in their neighborhoods are more likely than other households to contain at least one asthmatic. These housing and neighborhood effects, moreover, are *independent* of influence of socioeconomic status. However, even in the presence of a full range of available controls, black and, especially, Puerto Rican households remain far more likely to contain asthmatics than do white households. Of equal importance, the full set of controls accounts for less than half the effect for blacks, and only one-fifth the effect for Puerto Ricans. Thus, whereas housing and neighborhood conditions are important predictors of asthma prevalence among households in New York City, and help to explain at least part of the higher asthma levels for blacks and Puerto Rican Hispanics, these groups remain far more likely to suffer from this aspect of ill health than comparable white households.

DISCUSSION

The goal of this article was two-fold. The first was to document differentials in the prevalence of asthma for households from ten specific racial/ethnic groups. While other studies have examined differences between blacks and whites (e.g., Boardman et al. 2001; Miller 2001) and there has been some investigation of difference among Hispanic groups (Kinnert et al. 2002; Mendoza et al. 1991), little research has been done to date that includes Asians. Using data for New York City, I find significant variations in the prevalence of asthma, with Puerto Rican households most likely and Chinese, Asian Indian, and Mexican households far less likely to contain at least one asthmatic, even when group differences in household size are taken into account.

The second goal was to establish if differential exposure to potentially adverse housing and neighborhood conditions helped to explain at least part of the observed racial/ethnic disparities in asthma prevalence. Multilevel logistic regression models demonstrated that housing and neighborhood conditions were significantly associated with the presence of at least one asthmatic in the household. As expected, the odds of asthma prevalence rose strongly with the number of maintenance deficiencies reported by householders; were enhanced by dampness, lack of adequate heat, and by the presence of rodents; and were higher for households living in areas perceived to lack the safety and security of a socially cohesive neighborhood. Additional tests suggest that this latter result may partly reflect the increased vulnerability to asthma that results from increased stress or behaviors that increase exposure to indoor triggers, but the evidence is weak at best. To differentiate between the two mechanisms requires psychosocial measures and measures of everyday behaviors that are not available in this data set.

The findings regarding the influence of housing conditions, and especially the role played by maintenance deficiencies, point to the importance of strengthening both the laws regarding the correction of housing code violations and the programs aimed at helping landlords to make structural improvements in the face of high costs. Interventions, such as those embodied in "Healthy Homes" programs that provide comprehensive services, including the reduction of asthma triggers in the home, can help to reduce the severity of asthma (Krieger

and Higgins 2002; Kreiger et al. 2005; Nicholas et al. 2005). The potential importance of this type of intervention is underscored by the fact that the set of housing conditions was most strongly associated with the excess asthma morbidity exhibited by black and Puerto Rican households, and by the fact that the impact of these conditions relative to the other predictors is quite substantial. That is, while the standardized coefficients for Model III (not shown) reveal that race/ethnicity and household composition and headship have, by far, the largest effects on the prevalence of asthma, the presence of leaks has an effect that exceeds that of female headship (the weakest of the former set of variables). Moreover, the effects of heating breakdowns and needing additional heat also outweigh those of the majority of variables in the model. Thus, efforts to eliminate the indoor triggers arising from housing deterioration have great potential to not only reduce asthma rates generally, but also to reduce the excess morbidity exhibited by blacks and Puerto Ricans.

A growing body of research, however, indicates that community-based health interventions implemented by governmental agencies at any level have the greatest possibility of success when they involve inexpensive and easy-to-sustain changes in behavior, when they involve a personal dimension such as home visits by community health workers, and when they take into account the complex cultural, social, and political nature of the immediate context (Corburn 2002; Green et al. 2002; Saegert et al. 2003). The latter is most efficiently accomplished by involving local residents as equals in the planning and execution of a program, since only they can help researchers and scientists design interventions that make sense in, and can be easily incorporated into, community residents' daily lives (Corburn 2002).

Perhaps most significantly, I found that controlling for substandard housing and neighborhood conditions helped to account for a portion of the disadvantage experienced by black and Puerto Rican households. As the disproportionate exposure of black and Puerto Rican households to such conditions stems not from low socioeconomic status but from external constraints on their housing choices (Rosenbaum and Friedman 2007), discrimination in the housing market can be said to contribute to these groups' lower levels of health. Such a finding adds to the growing literature docu-

menting a connection between racism and health (e.g., Williams and Collins 1995), and it points to the need to strengthen fair housing laws and their enforcement to, once and for all, make access to safe and desirable housing available to all households.

Inevitably, though, the limitations inherent to this study may also contribute to findings of varying risks of asthma net of all predictors. In addition to the need for measures to differentiate between the potential indirect pathways, a clear limitation is the absence of information in the data set on health behaviors and other characteristics of individual household members, as well as other factors relating to a predisposition to respiratory ailments. It is also possible that the unique circumstances of New York City, with its persistently high levels of segregation and its extremely high levels of asthma, contribute to the findings of persistent differentials. To better understand the disproportionate asthma risks faced by Puerto Ricans and blacks, it is essential that data sets containing all potentially relevant predictors be collected for a variety of different areas, and for individuals (rather than households).

The fundamental nature of race/ethnicity as a cause of disease (Link and Phelan 1995), so clearly evident here, means that any intervention that focuses only on the mechanisms linking physical context and disease will never be truly effective. Rather, until the social, economic, and political forces (including housing market discrimination) that maintain the racial/ethnic hierarchy of access to healthy environments are dismantled, morbidity and mortality rates will continue to be disproportionately higher for those at and near the bottom of the hierarchy.

APPENDIX. Household Characteristics of New York City Households, by Race/Ethnicity of Householder, 2002 (percentages except where noted)

Characteristics		Race/Ethnicity of Householder									
	White	Black	Puerto Rican	Dominican	Cent./S. American	Mexican	Other Hispanic	Chinese	Asian Indian	Other Asian
Foreign-born householder[a]	28.33	39.36	58.08	90.76	91.71	89.32	69.67	91.68	96.65	82.59
Mean age of householder	50.93	48.25	48.18	43.76	44.14	33.56	48.42	47.60	42.21	46.11
Householder's education										
Less than high school	10.17	22.77	42.85	45.77	34.46	58.34	23.04	35.49	14.56	13.57
High school diploma	23.33	28.96	27.11	23.05	28.68	26.12	27.07	25.44	27.31	21.47
Some college or more	66.50	48.26	30.04	31.18	36.87	15.55	49.89	39.08	58.13	64.96
Female householder	34.60	49.69	48.51	53.05	33.34	13.70	37.82	19.24	11.35	27.59
Presence of children 0–12										
None	83.33	66.20	65.68	54.65	56.29	48.19	76.84	70.60	53.81	73.94
One	8.29	18.99	18.65	23.41	22.92	23.03	12.14	16.44	19.43	15.32
Two or more	8.37	14.81	15.68	21.95	20.78	28.78	11.02	12.96	26.76	10.75
Presence of children 13–17	6.94	17.26	17.83	22.94	18.27	15.20	9.24	17.05	19.26	13.91
Household income/10,000 (mean)	8.08	4.44	3.28	3.26	4.54	4.37	4.91	5.34	5.47	6.73
Receives TANF	0.00	4.00	5.00	7.00	2.00	5.00	2.00	1.00	0.00	0.00
Lived in unit 5+ years	64.70	67.70	66.20	65.63	55.94	42.29	63.29	58.33	53.31	53.88
N of cases	5,238	2,863	1,130	665	615	149	236	429	344	388

NOTES

1. Almost 14 percent of all occupied housing units have missing data on the dependent variable, the presence of any asthmatics within the household, and on a theoretically key predictor, the presence of smokers. The degree of missing data for these variables likely derives from prematurely ended interviews, as these items are at the end of the questionnaire, following such sensitive questions as income and public assistance receipt. Households with missing data on asthma prevalence are more advantaged than are those with valid asthma information (with higher incomes and a higher degree of home ownership, for example), and they are more likely to be white. Thus, if full information had been available on asthma prevalence, it is likely that the observed racial/ethnic differentials would have been even greater.

2. The number of children of different ages was chosen as the indicator of household size (rather than the total number of household members) given the variation in asthma prevalence by age. Data from the 2002 National Health Interview Survey show that lifetime asthma prevalence is higher for those under 18 than for those over 18, and it peaks in the 15 to 19 age group (Centers for Disease Control 2002).

3. Although island-born Puerto Ricans are not immigrants, research has noted differences in health favoring Puerto Ricans born on the island relative to those born on the mainland (e.g., Landale, Oropesa, and Gorman 2000).

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