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Are Neighborhood-Level Characteristics Associated with Indoor Allergens in the Household?

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Abstract

Background—Individual home characteristics have been associated with indoor allergen exposure; however, the influence of neighborhood-level characteristics has not been well-studied. We defined neighborhoods as community districts determined by the New York Department of City Planning.

Objective—We examined the relationship between neighborhood-level characteristics and the presence of dust mite (Der f 1), cat (Fel d 1), cockroach (Bla g 2), and mouse (MUP) allergens in the household.

Methods—Using data from the Puerto Rican Asthma Project, a birth cohort of Puerto Rican children at risk of allergic sensitization (n=261) we examined associations between neighborhood characteristics (percent tree canopy, asthma hospitalizations per 1000 children, roadway length within 100 meters of buildings, serious housing code violations per 1000 rental units, poverty rates, and felony crime rates) and the presence of indoor allergens. Allergen cutpoints were used for categorical analyses and defined as follows: dust mite: >0.25 μg/g; cat: >1 μg/g; cockroach: >1 U/g; mouse: >1.6 μg/g.

Results—Serious housing code violations were statistically significantly positively associated with dust mite, cat and mouse allergens (continuous variables), adjusting for mother's income and education, and all neighborhood-level characteristics. In multivariable logistic regression analyses, medium levels of housing code violations were associated with higher dust mite and cat allergens (1.81, 95%CI: 1.08, 3.03 and 3.10, 95%CI: 1.22, 7.92, respectively). A high level of serious housing code violations was associated with higher mouse allergen (2.04, 95%CI: 1.15, 3.62). A medium level of housing code violations was associated with higher cockroach allergen (3.30, 95%CI: 1.11, 9.78).

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Conclusions—Neighborhood-level characteristics, specifically housing code violations, appear to be related to indoor allergens, which may have implications for future research explorations and policy decisions.

Keywords

indoor allergens; dust mite; cat; cockroach; mouse; asthma; neighborhoods; community districts; housing code violations; policy; New York City; Puerto Rican

Introduction

In the United States, there is a large body of literature showing an association between neighborhood characteristics and health outcomes. (1) For instance, both neighborhood poverty and negative social climate contribute to child behavior problems. (2,3) Yet, favorable neighborhood characteristics can also result in positive health outcomes. For example for adolescents, living in a neighborhood with a higher concentration of organizations or services for children and adults was associated with lower levels of youth aggression. (4) Asthma, a chronic disease of the lungs characterized by narrowing airways and recurrent breathing problems, affects 22.9 million Americans. (5-7) Despite the breadth of work concerning neighborhoods and health, only a few studies have examined the relationship between neighborhood-level characteristics and asthma. Previous research demonstrated that neighborhood-level characteristics such as neighborhood violence (8,9) and pollution (10-14) are related to asthma morbidity (15-19). Also, not only do African Americans and Hispanics have a much higher risk of preventable asthma hospitalization than non-Hispanic Whites (20) but the racial composition of a neighborhood (i.e. proportion of African American and Hispanics) is associated with asthma hospitalization rates. (16) In addition, low-income areas have a disproportionate prevalence of childhood asthma. (21,22)

Indoor allergen exposure is a risk factor for allergic sensitization, asthma development, and asthma morbidity. Although, previous work indicates that neighborhood characteristics are related to asthma morbidity, and asthma morbidity is related to indoor allergens, to our knowledge, no studies have specifically examined the association of neighborhood-level characteristics and the presence of indoor allergens. (21-25)

Neighborhood-Level

Asthma triggers, such as allergens, at the household or housing unit level have been widely investigated in the public health literature (23-48). Sensitization to cockroach allergen is widely known to be associated with asthma. (49-51) High exposure to cockroach allergen and concomitant cockroach allergy is a risk factor for asthma medication use and asthma-related hospitalizations. (30) Sensitization to indoor allergens (e.g. from to dust mites, cats, cockroaches, and mice) can be related to airway hyperresponsivesness (52), and wheezing. (53) Increased exposure to allergens, particularly dust mites and cockroaches, is related to an increased likelihood of developing asthma. (29,54,55)

Some indoor allergens (e.g., cockroach and mouse) are more prevalent in low-income inner-city areas; this suggests the possible role of both housing deterioration and disadvantaged neighborhood conditions concerning the presence of indoor allergens. (56-63) In low-income urban neighborhoods such as the Bronx and East Harlem, asthma morbidity is associated with high-levels of indoor allergens. (25,30,35,40) We explored the association between neighborhood-level characteristics (environmental and social neighborhood exposures) and the following indoor allergens: dust mite (Der f 1), cat (Fel d 1), cockroach (Bla g 2), and mouse (MUP) in a birth cohort of Puerto Rican children in the Bronx, New York.

Specifically, we explored the following neighborhood characteristics: percent tree canopy, asthma hospitalization rates, mean roadway length, serious housing code violations, poverty rate, and felony crime rate. Neighborhood poverty (64,65), and neighborhood violence are related to asthma. (8,9,45,66-68). The proportion of tree canopy or trees, a measure of surface area covered by overhanging vegetation, is often recognized for its health benefits (69), though this is not always the case. (70) Neighborhood asthma hospitalization rates may signal differential access to health care, neighborhood resources, or polluting sources. (16) Considerable literature in environmental health explains that proximity to concentrations of noxious particles released by vehicles may exacerbate asthma development and severity (12,68,71-75); GIS traffic measures are often used as proxies to capture exposure to traffic-related pollutants associated with asthma. (76-79) Lastly, research suggests that housing violations may be related to asthma morbidity. (35,80)

We hypothesized that these neighborhood-level characteristics are associated with the presence of indoor allergens in the household.

Methods

We examined the relationship between neighborhood-level characteristics and indoor allergens using data from the Puerto Rican Asthma Project (PRAP). Puerto Ricans are one of the racial/ethnic groups most severely affected by asthma in the United States. (40,81-90) The PRAP is a prospective birth cohort of Puerto Rican children born in New York City (NYC) – primarily in the Bronx – who were at risk for development of childhood asthma. Full study details have been discussed previously. (91) Briefly, 274 mothers, and their newborns, completed the initial baseline home visit (the source of allergen measurements for this paper) which occurred within a few weeks after the birth of their child. Participant mothers answered questions on behalf of her household and child in either Spanish or English. A team of two technicians, one of whom was bilingual (Spanish/English), collected environmental samples and administered a questionnaire to the mother. During this baseline visit, the surface of the mother's bed was vacuumed for three minutes and samples were analyzed for dust mite (Der f 1), cockroach (Bla g 2), cat (Fel d 1), and mouse (MUP) allergens as previously described by Acosta, et al (2008).

At baseline, 12 participants were excluded because they were not available in OASIS (New York City Open Accessible Space Information System Cooperative). Of these 12, eight lived outside the five NYC boroughs and four addresses could not be located in OASIS. An additional participant was dropped from analyses because a sibling was already enrolled in the study. Thus, at baseline, 261 participants remained for analysis. The Human Subjects Committee at the Harvard School of Public Health and at Columbia University Medical Center approved this study.

Allergen Outcome Measures

Allergen levels were ln-transformed to approximate normality in linear regression models that examined associations with neighborhood-levels characteristics. Categorical analysis (logistic regression) was also used to explore previously published allergen level thresholds for allergic sensitization, when possible (cockroach >1 U/g [1 unit = 40 ng] and mouse > 1.6 μg/g); and if this was not possible, the detection limits of the relevant immunoassay were used (dust mite > 0.25 μg/g; cat > 1 μg/g). (29,30,39,41,49,92)

Neighborhood Exposure Measures

Neighborhood was defined as a NYC community planning district, a spatial unit created by the New York Department of City Planning used to organize new and redeveloping projects.

NYC has 59 community districts, and the average population in each community district was 135, 734. The Bronx, where the majority of study participants lived, has 12 community districts. (93) The average population of community districts in the Bronx was 106,775. Neighborhood-level data were collected from the OASIS database (www.oasisnyc.net) from March-April 2007 using participants' addresses. (69) The neighborhood characteristics from OASIS were percent tree canopy (measure of tree canopy cover: amount of surface area covered by overhanging vegetation) and asthma hospitalizations per 1000 children. OASIS is a web-based Geographic Information Systems (GIS) mapping resource for NYC. It is a partnership of more than 30 federal, state, and local agencies, private companies, academic institutions, and nonprofit organizations, creating a one-stop, interactive mapping and data analysis application via the Internet. Each participant address was entered into the OASIS mapping system to collect neighborhood characteristics data. Each address was entered a minimum of three different times, when necessary. If the address still could not be located, the participant was dropped from the analysis. All study participant addresses were geocoded by the commercial geocoding firm, Mapping Analytics. (94) Neighborhood characteristics data were also collected from The State of New York City's Housing and Neighborhoods, 2006 (The Furman Center for Real Estate and Urban Policy). (95) These characteristics were serious housing code violations per 1000 rental units (a serious violation is a Class C [immediately hazardous] assigned by the NYC Department of Housing Preservation and Development), poverty rate (calculated by the NYC Housing and Vacancy Survey using income data, and income cutoffs or "poverty thresholds"), and the felony crime rate per 1000 people (the seven major felony crimes used are: burglary, larceny, motor vehicle theft, murder, rape, robbery, and assault). (69,95) In ArcGIS 9.2, using StreetMap USA, we calculated distance to nearest highway from residences, and congestion (96) and mean roadway length within a 100 meter radius of participants' residences. (97) These measurements were not available at the community district level. In this study, participants' traffic exposures were standardized across measures, and the one with the best variability for this cohort was used; here, this was mean roadway length within a 100 meter radius of participants' residences. (79) For both roadway length and serious housing code violations, we created three categories for analysis, spreading the data out as evenly as possible across the three groups. We reached an even spread with roadway length, achieving tertiles (n=87, 87, 87); however serious housing code violations could not be divided into tertiles due to the number participants who had the same amount of violations, overlapping across categories. Therefore, as a category, serious housing violations, was grouped as follows: n=70, 91, 99.

Covariates—Mother's education and household income were measured in the baseline interview survey and were dichotomized: *education* (≤ high school graduate (referent) or ≥ some college); *household income* ((≤ $39,999 (referent) or ≥ $40,000+). Building-level violations for each address were collected by linking to the NYC Department of Buildings (DOB), Property Profile Overview to obtain the number and type of violation for each address. (98) An Environmental Control Board (ECB) violation is a notice that a property does not comply with a provision of the NYC Building Code and/or NYC Zoning Resolution, and such violations are resolved at the Environmental Control Board, an administrative law court where a violator must (a) pay a civil penalty and correct the violating condition, and (b) file a Certificate of Correction with the DOB. (99) Violations were standardized by building age and number of units in the building, and then multiplied by 100 for ease of interpretability.

Sociodemographic Variables—During the baseline interview survey, participants' mothers were asked their about marital status (married, divorced, separated, widowed, never been married), birth place (Mainland, USA, Puerto Rico, Dominican Republic, Mexico, Other), and how long they had been in the U.S. (number of years).

Analysis

We evaluated the association ($p<0.05$) between neighborhood exposures and allergen levels, using bivariate and multivariable linear regression, as well as logistic regression for allergen threshold levels as specified earlier. Possible confounders (income and education) were included in all subsequent analyses.

In initial bivariate linear models we examined the relationship of each neighborhood exposure to the allergen levels. The first set of multivariable linear models examined the same relationships, while also adjusting for income and education. The next set of multivariable analyses examined social neighborhood exposures, and then environmental neighborhood exposures, in relation to the allergen levels. We then explored fully adjusted multivariable models, where each parameter estimate was adjusted for all other predictor variables in the model, including income and education. All ratios and 95% confidence intervals for linear models were back-transformed to represent the original allergen scales instead of log-scales.

We also fitted multivariable logistic models for each allergen according to its limit of detection or allergic sensitization cutpoint, as found in the literature (dust mite: >0.25 μg/g; cat: >1 μg/g; cockroach: >1 U/g [40 ng/g]; mouse: >1.6 μg/g). (29,30,39,41,49,92) In addition to following the modeling strategy described above for multivariable linear regression, in multivariable logistic models, we also adjusted for building-level violations (ECB + DOB violations). Lastly, we examined spatial representations of neighborhood characteristics and the outcomes in ArcGIS 9.2. All other analyses were performed in SAS 9.1 and JMP 7.0. (100,101)

Results

Sample

Most mothers had never been married (64.8%) and were born on the Mainland USA (73.6%), while 20.7% were born in Puerto Rico. In addition, 56.3% of mothers had a high school education or less and 80.8% lived in households where the combined family income was less than $39,999/year. In participants' neighborhoods, the average percent of tree canopy was 10.3, and the average asthma hospitalization rate per 1000 children was 16.7. Participants' buildings had an average of 555.3 meters of roadway within a 100 meter radius of their buildings. Participants' neighborhoods were also characterized by an average of 106.4 serious housing code violations per 1000 rental units, a neighborhood poverty rate of 30.2%, and a felony crime rate of 31.2% per 1000 people. (Table 1) NYC community districts where participants lived were compared to NYC community districts where no study participants lived to examine study exposures. We found that community districts where study participants lived generally shared a higher burden of neighborhood-level characteristics that have been shown to relate to asthma in the neighborhood literature. (8,35,65,67-[70],72,79,80,102) Study participants lived in community districts that had 4% more tree canopy, a 136% higher asthma hospitalization rate, a 164% higher housing code violations rate, a 68% higher poverty rate, and an 11% higher felony crime rate than those community districts where there were no study participants. (Table 2)

Descriptive statistics of the indoor allergens are presented in Table 3. When dust mite allergen was detected, the concentrations were low compared with those of cockroach, mouse and cat allergens. The variation in cat allergen was markedly greater than that of the other allergens. Some homes were missing dust samples, primarily because not enough dust was collected from the bed surface.

Multivariable Analysis

Dust mite (Der f 1)—As can be seen in Table 4, no statistically significant associations were found in any bivariate models between dust mite and neighborhood-level characteristics. In fully-adjusted models, a statistically significant association was found between a medium level of serious housing code violations and the presence of dust mite allergen (1.81, 95%CI: 1.08, 3.03). When dust mite allergen was dichotomized into a level of detectable vs. not detectable, it was no longer associated with a medium level of serious housing code violations in fully adjusted models.

Cats (Fel d 1)—As can be seen in Table 5, a bivariate statistically significant relationship was found between a medium level of housing code violations and cat allergen (2.01, 95%CI: 1.06, 3.78). This association was maintained in fully adjusted models (3.10, 95%CI: 1.22, 7.92). When at allergen was dichotomized using as a cutpoint levels >1 μg/g, it was no longer associated with medium levels of serious housing code violations in fully adjusted models.

Cockroaches (Bla g 2)—As can be seen in Table 6, in bivariate models, statistically significant associations were found between the asthma hospitalization rate per 1000 children (1.05, 95%CI: 1.02, 1.10), a medium (2.61, 95%CI: 1.64, 4.15) and a high (1.60, 95%CI: 1.01, 2.54) level of serious housing code violations, the poverty rate (1.03, 95%CI: 1.02, 1.05), and the felony crime rate (1.05, 95%CI: 1.02, 1.08), and the presence of cockroach allergen. None of these associations remained statistically significant in fully adjusted analyses. In logistic regression analysis, a medium level of housing code violations was associated with cockroach allergen at levels >1 U/g [40 ng/g] in fully adjusted models (3.30, 95%CI: 1.11, 9.78).

Mice (MUP)—As can be seen in Table 7, statistically significant associations were found in bivariate models between the asthma hospitalization rate (1.03, 95%CI: 1.00, 1.06), a high level of serious housing code violations (1.80, 95%CI: 1.30, 2.48), and the poverty rate (1.01, 95%CI: 1.00, 1.03) and mouse allergen levels. Only the association between a high level of serious housing code violations mouse allergens persisted in fully adjusted models (2.04, 95%CI: 1.15, 3.62). In logistic regression analysis, a high level of serious housing code violations was associated with mouse allergen at levels >1.6 μg/g in fully adjusted models (7.87, 95% CI: 1.12, 55.24).

Adjusting for Building-Level Violations—As can be seen in Tables 4-7, in multivariable logistic models, statistically significant associations between neighborhood-level housing violations and indoor allergens persisted after adjusting for building-level violations A medium level of neighborhood serious housing code violations was statistically significantly associated with cockroach allergen after adjusting for DOB and ECB building level housing violations separately. A high level of serious neighborhood housing code violations was statistically significantly associated with mouse allergen after adjusting for building level housing code violations.

Discussion

Our primary objective was to determine if any relationship existed between neighborhood characteristics and the presence of indoor allergens, since this had not been previously studied. We examined the relationship between various neighborhood-level predictors and the presence of indoor allergens in the household, even after adjusting for building-level housing code violations. Previous studies have explored the relationship between housing conditions and indoor allergens. Concerning dust mite and cat allergen, previous literature has been inconsistent in its reporting of the relationship between housing conditions and the presence of these allergens. Therefore it is difficult to assess whether our results demonstrating an association between neighborhood-level housing code violations and dust mite/cat allergens in multivariate linear models is consistent with previous findings concerning the housing unit level. (103)

Previous studies have found a relationship between poor housing conditions and the presence of cockroach allergen (35,58,104) and elevated mouse allergen. (58,104) We demonstrated an association between cockroach and mouse allergen, and the prevalence of housing code violations at the neighborhood level even after adjusting for building level housing code violations. Graphically, the relationship between serious housing code violations and the presence of mouse allergen can be seen in Figure 1, which shows neighborhoods with high levels of housing code violations to overlap neighborhoods with higher levels of mouse allergen. Overall, these relationships suggest that, where many of the leading indoor allergens are concerned, we may need to consider prevention and treatment options at the neighborhood-level. Though more work is needed to determine the relationship between neighborhood factors and the presence of allergens, it seems that reducing serious housing code violations may decrease exposure to allergens, which are related allergic sensitization and asthma.

This study had a few limitations. First, while this was a prospective birth cohort, we only assessed allergen measurements and neighborhood-level characteristics cross-sectionally. Therefore, no causal statements can be made. Furthermore, these analyses were limited to a small baseline cohort sample (N=261) of Puerto Rican participants with a history of mother inhalant allergy or asthma. Therefore, we can not generalize beyond this population. Furthermore, limitations existed in the actual measurement of exposures. Many neighborhood-level exposures were proxy variables, (e.g. mean roadway length), while still other relevant variables were unavailable (e.g. specific types of neighborhood housing code violations). Since one of our major findings was the importance of neighborhood-level housing code violations, it seemed important to adjust for building-level violations to see if this mediated any of the neighborhood level effect. It did not, and in fact, adjusting for building-level violations strengthened the neighborhood effect.

However, it is clear that the neighborhood-level and building-level housing code violations were not drawn in the same way in the New York City data systems we used for this analysis. Furthermore, even though we did not achieve perfect tertiles with the serious housing code violations variable, the amount of violations in the medium and high categories were so egregious that such findings seem plausible given previous literature, and subsequent analyses controlling for building-level house code violations. Lastly, since some participants were missing dust samples, because not enough dust was drawn, results could be biased. Yet allergen levels in this study were comparable to other New York City studies examining indoor allergens. (39,58) Compared to other non New York City-specific studies measuring indoor allergens, our levels of cat and dust allergen were generally low, while levels of cockroach and mouse allergen were generally high. The levels in our study are not comparable to national data, since such data are less representative of urban areas with high population density and high density of high-rise buildings. (37,41,46,105)

Despite these limitations, this work suggests avenues for additional research. First, future research should further explore the association between neighborhood-level characteristics and the presence of indoor allergens. Currently, neighborhood-level factors are not considered in asthma prevention strategies. For example, the most recent “Guidelines for the Diagnosis and Management of Asthma” from the National Asthma Education and Prevention Program does not discuss neighborhood-level factors. (106) However, Wright and colleagues have discussed neighborhood factors in terms of asthma prevention. (8,67,107,108)

Increasingly, urban planning and public health researchers and practitioners are aware of the need for collaboration between these two fields. (16,109-114) This study suggests some ways in which such collaborations may happen. For example, the New York City Department of City Planning can target "high-risk" community districts (those with high levels of housing code violations, for example). The Department could include a health objective on future building and planning bids, and require future projects to discuss how a new project would solve, prevent, or alleviate health concerns. For example, if a developer is interested in creating a new mixed-use space in the Bronx near the Cross-Bronx Expressway, she would need to explain how the firm is taking measures to mitigate the harmful air and noise pollution byproducts of the expressway that might be experienced by future commercial and residential tenants. In addition, she might explain how the project would prevent dust from spreading into neighboring areas while the project is being constructed, and how the project plans to minimize construction noise. In partnership with the NYC Department of Mental Health and Hygiene, and the Department of City Planning, the City of New York could be a model for consciously combining these issues of the built environment and health into its work practice. The Furman Center has several data indicators at the community district level which can be helpful to projects which consider both built environment and health issues; these indicators include elevated blood lead levels, infant mortality rate, low birth weight rate, severe crowding rate, tax delinquencies, racial diversity index, rental units that are subsidized, and residential units within ¼ mile of a park. (95)

Future studies should incorporate a larger city-wide, or nationally, representative sample of U.S. participants to further clarify the relationship between neighborhood characteristics and asthma morbidity and mortality. The focus on Puerto Ricans in this study was important, since the asthma burden is so high in this population, but future studies should aim to clarify the relationship of neighborhood-level issues and asthma morbidity in a representative sample. The use of multilevel modeling will help to isolate neighborhood, building and individual level effects. (115)

Such future studies should also further extend the measurement of neighborhood characteristic variables, which was not possible in this study. Though it is certainly positive that the area level data used in this study was publicly available, we need to continue working toward fuller measurement. Future studies might more precisely examine the relationship between neighborhood traffic pollutants (116-119), specific types of housing code violations (35,80) and asthma morbidity. For example, available data on serious housing code violations may have actually underestimated the relationship with asthma-related allergens since it only pertained to one class of housing violations, and did not include NYC public housing. (120) Future studies should both collect their own neighborhood-level data, and request more publicly available data from governmental entities, e.g. housing and planning agencies.

The definition of neighborhood is also an important issue for future work. Two important concerns informed the decision to use community planning districts as the spatial unit in our work, although most current thought in spatial epidemiology suggests the use of smaller spatial areas (e.g. census tracts). (121) First, the sample size was too small to consider spatial areas aside from these districts; it would have been difficult to consider participants' outcomes and area level issues if so few of them were within each spatial unit. (122) Second, the NYC Department of City Planning uses these districts to design and implement redevelopment as well as new building and neighborhood projects. Therefore, districts are spatial units with policy and planning relevance, and employing them in public health research may serve as a vehicle to link health issues to indicators regularly maintained by government officials, including information on housing types, parks, vacant land, commercial space, and facilities. (123-125)

City agencies, such as health departments, transportation and planning boards, the police, and housing authority, wield a good deal of power over the health of neighborhood residents. Community district policies regarding incentives for landlords for fewer housing violations and quicker remediation if violations occur might be useful remedies to reduce asthma burden. Likewise, planning boards might instruct architects and developers to explicitly incorporate health objectives into their design plans. A health lens needs could be used to assess the possible health effects of urban polices and programs, for example through the application of a methodology such as Health Impact Assessment.

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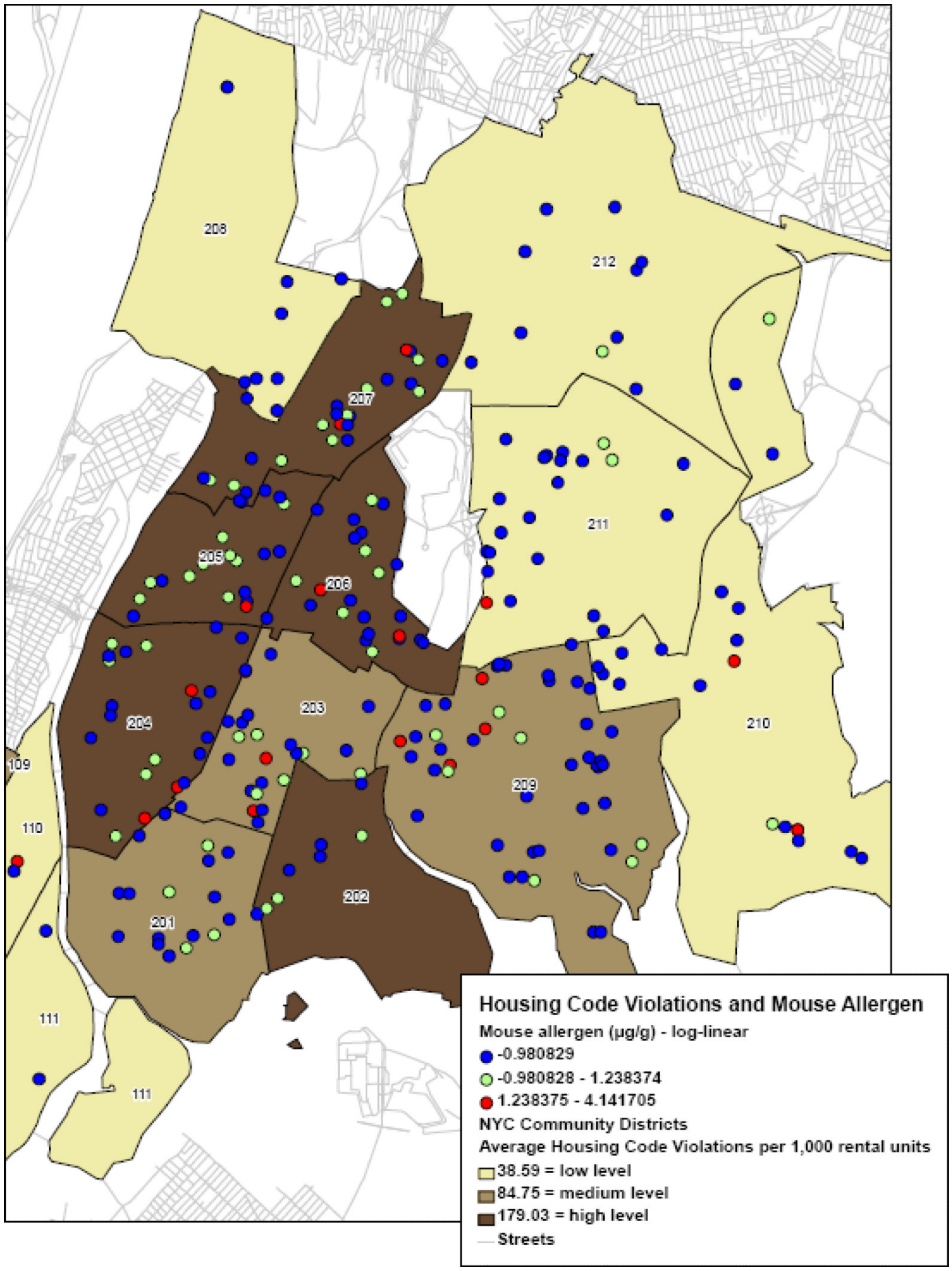

Figure 1.
Housing Code Violations and Mouse Allergen (MUP), Bronx, New York

Table 1

Demographic and Neighborhood-Level Characteristics (n=261)

Built Environment Neighborhood Exposures	Mean	SD	Missing
% Tree Canopy	10.33	5.26	--
Asthma Hospitalization Rate per 1000 children	16.67	4.88	--
Mean Roadway Length within 100 meter radius of bldg	555.30	146.30	--
Mean Roadway Length within 100m (meters)	396.41	69.68	
Mean Roadway Length within 100m (meters)	556.18	35.94	
Mean Roadway Length within 100m (meters)	713.32	88.05	
Housing Code Violations per 1000 people	106.36	61.63	1
Housing Code Violations per 1000 people	39.04	17.79	
Housing Code Violations per 1000 people	78.79	18.95	
Housing Code Violations per 1000 people	179.29	13.03	

Social Environment Neighborhood Exposures	Mean	SD	Missing
Poverty Rate	30.23	9.93	1
Felony Crime Rate per 1000 people	31.24	7.40	1

Mother's Demographic Characteristics	N	%	Missing
Marital Status			--
Married	75	28.74	
Divorced	7	2.68	
Separated	9	3.45	
Widowed	1	0.38	
Never been married	169	64.75	
Maternal Birthplace			--
Mainland USA	192	73.56	
Puerto Rico	54	20.69	
Dominican Republic	10	3.83	
Mexico	2	0.77	
Other	3	1.15	
Education			--
High school grad or equivalent, or less	147	56.32	
Some college or more	114	43.68	
Income			--
≤ $39,999	211	80.84	
$40,000+	50	19.16	

	Mean	SD	Missing
Maternal Years in Mainland U.S.	23.44	7.12	--

Table 2

Comparisons between New York City (NYC) and Puerto Rican Asthma Project Community District Weighted Averages

	All NYC Community Districts (59)	Non Puerto Rican Asthma Project Community Districts (42)	Puerto Rican Asthma Project Commuity Districts (17)	Puerto Rican Asthma Project Bronx Only Community Districts (12)
NYC Community District Exposures				
% Tree Canopy	12.93	12.8	13.34	11.81
Asthma Hospitalization Rate per 1000 children	8.91	6.69	15.76	15.83
Housing Code Violations per 1000 rental units	50.96	36.38	96.03	102.85
Poverty Rate	17.94	15.38	25.83	28.58
Felony Crime Rate per 1000 people	27.26	26.55	29.48	29.35

Table 3

Indoor Allergens at Baseline

	N	Median	Missing	Geometric Mean	Geometric SD
Der f 1 μg/g (dust mite)	245	0.125	16	0.20	2.98
Fel d 1 μg/g (cat)	253	0.48	8	0.64	7.66
Bla g 2 U/g* (cockroach)	221	0.50	40	1.46	4.10
MUP μg/g (mouse)	241	0.38	20	0.63	2.81

*Bla g 2 U/g [40 ng/g]

Table 4

Bivariate and multivariable associations of neighborhood characteristics and indoor allergens: Puerto Rican Asthma Project (n=261)

	Dust Mite Allergen (Der f 1)				Cat Allergen (Fel d 1)			
	Bivariate[◊]	Multivariable[◊*]	Logistic[*]	Logistic[**]	Bivariate[◊]	Multivariable[◊*]	Logistic[*]	Logistic[**]
BUILT ENVIRONMENT NEIGHBORHOOD EXPOSURES								
% Tree Canopy	0.99 (0.97, 1.02)	1.00 (0.97, 1.03)	1.00 (0.92, 1.08)	1.00 (0.92, 1.08)	1.03 (0.98, 1.08)	1.05 (0.99, 1.11)	1.03 (0.97, 1.09)	1.04 (0.98, 1.10)
Asthma Hospitalization Rate per 1000 children	0.98 (0.95, 1.01)	1.00 (0.94, 1.06)	0.97 (0.80, 1.17)	0.97 (0.81, 1.17)	0.99 (0.94, 1.05)	0.98 (0.88, 1.09)	0.97 (0.86, 1.10)	0.98 (0.86, 1.11)
Roadway Length within 100 meter radius of bldg								
Mean Roadway Length within 100 meters [1]	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Mean Roadway Length within 100 meters [2]	0.88 (0.63, 1.23)	0.93 (0.66, 1.31)	0.65 (0.28, 1.50)	0.65 (0.28, 1.49)	0.63 (0.34, 1.16)	0.81 (0.43, 1.50)	0.98 (0.50, 1.92)	0.97 (0.50, 1.90)
Mean Roadway Length within 100 meters [3]	0.88 (0.63, 1.23)	0.97 (0.67, 1.40)	1.20 (0.52, 2.77)	1.19 (0.52, 2.76)	0.91 (0.49, 1.68)	1.31 (0.68, 2.53)	1.20 (0.59, 2.45)	1.18 (0.58, 2.42)
Housing Code Violations per 1000 rental units								
Housing Code Violations per 1000 rental units [a]	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Housing Code Violations per 1000 rental units [b]	1.20 (0.84, 1.71)	1.81 (1.08, 3.03)	2.99 (0.85, 10.51)	2.90 (0.83, 10.18)	2.01 (1.06, 3.78)	3.10 (1.22, 7.92)	1.92 (0.70, 5.21)	1.87 (0.69, 5.10)
Housing Code Violations per 1000 rental units [c]	0.96 (0.68, 1.36)	1.82 (0.99, 3.36)	4.36 (0.87, 21.86)	4.21 (0.85, 20.93)	1.03 (0.56, 1.90)	2.14 (0.71, 6.43)	1.29 (0.38, 4.37)	1.27 (0.38, 4.29)
SOCIAL ENVIRONMENT NEIGHBORHOOD EXPOSURES								
Poverty Rate	0.99 (0.98, 1.00)	0.95 (0.89, 1.00)	0.88 (0.75, 1.02)	0.88 (0.76, 1.02)	1.01 (0.98, 1.03)	0.94 (0.85, 1.04)	0.95 (0.85, 1.07)	0.95 (0.85, 1.07)
Felony Crime Rate per 1000 people	0.99 (0.97, 1.01)	1.04 (0.98, 1.10)	1.11 (0.96, 1.28)	1.10 (0.96, 1.27)	1.02 (0.99, 1.06)	1.08 (0.98, 1.20)	1.06 (0.94, 1.18)	1.05 (0.94, 1.18)

	Cockroach Allergen (Bla g 2)				Mouse Allergen (MUP)			
	Bivariate[◊]	Multivariable[◊*]	Logistic[*]	Logistic[**]	Bivariate[◊]	Multivariable[◊*]	Logistic[*]	Logistic[**]
BUILT ENVIRONMENT NEIGHBORHOOD EXPOSURES								
% Tree Canopy	0.97 (0.94, 1.00)	0.99 (0.95, 1.03)	0.95 (0.89, 1.03)	0.95 (0.88, 1.03)	0.98 (0.96, 1.01)	1.00 (0.97, 1.03)	0.99 (0.90, 1.09)	0.98 (0.88, 1.08)
Asthma Hospitalization Rate per 1000 children	1.05 (1.02, 1.10)	1.00 (0.92, 1.08)	0.99 (0.87, 1.12)	0.98 (0.86, 1.12)	1.03 (1.00, 1.06)	1.00 (0.94, 1.05)	0.94 (0.74, 1.19)	0.87 (0.66, 1.14)
Roadway Length within 100 meter radius of bldg								
Mean Roadway Length within 100 meters [1]	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Mean Roadway Length within 100 meters [2]	0.70 (0.44, 1.10)	0.75 (0.48, 1.18)	0.77 (0.37, 1.58)	0.77 (0.37, 1.60)	0.95 (0.69, 1.31)	0.88 (0.64, 1.22)	0.56 (0.22, 1.47)	0.48 (0.17, 1.30)
Mean Roadway Length within 100 meters [3]	0.80 (0.50, 1.27)	0.89 (0.55, 1.45)	1.06 (0.49, 2.31)	1.02 (0.46, 2.23)	1.09 (0.78, 1.50)	0.95 (0.67, 1.34)	0.74 (0.28, 1.94)	0.71 (0.27, 1.91)
Housing Code Violations per 1000 rental units								
Housing Code Violations per 1000 rental units [a]	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Housing Code Violations per 1000 rental units [b]	2.61 (1.64, 4.15)	1.56 (0.80, 3.06)	3.30 (1.11, 9.78)	3.22 (1.07, 9.65)	1.21 (0.87, 1.68)	1.28 (0.79, 2.08)	2.51 (0.49, 12.84)	3.69 (0.62, 21.99)
Housing Code Violations per 1000 rental units [c]	1.60 (1.01, 2.54)	1.11 (0.51, 2.45)	1.68 (0.46, 6.15)	1.65 (0.45, 6.07)	1.80 (1.30, 2.48)	2.04 (1.15, 3.62)	7.87 (1.12, 55.24)	12.95 (1.43, 117.01)
SOCIAL ENVIRONMENT NEIGHBORHOOD EXPOSURES								
Poverty Rate	1.03 (1.02, 1.05)	1.01 (0.93, 1.08)	1.01 (0.89, 1.14)	1.01 (0.89, 1.14)	1.01 (1.00, 1.03)	0.98 (0.93, 1.04)	0.96 (0.82, 1.12)	0.95 (0.81, 1.12)
Felony Crime Rate per 1000 people	1.05 (1.02, 1.08)	1.02 (0.95, 1.10)	1.01 (0.90, 1.14)	1.01 (0.90, 1.14)	1.01 (1.00, 1.03)	1.02 (0.97, 1.07)	1.05 (0.91, 1.22)	1.10 (0.93, 1.29)

◊ Ratios and the 95% confidence intervals were back-transformed to original scale instead of log scale.

* Multivariable and Logistic results: each parameter estimate is adjusted for all other variables in the model, including income and education.

** Each parameter estimate is adjusted for all other variables in the model, including income, education, and building violations [DOB (Department of Building) and ECB (Environmental Control Board) violations].

Mean Roadway Length: [1] 396.4 [2] 556.2 [3] 713.3

Housing Code Violations / 1000 rental units: [a] 39.0 (n=70) [b] 78.8 (n=91) [c] 179.3 (n=99)

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