

Deteriorated Housing Contributes to High Cockroach Allergen Levels in Inner-City Households

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The high prevalence of childhood asthma in low-income, inner-city populations is not fully understood but has been at least partly attributed to the disproportionate exposures associated with socioeconomic disadvantage. The contribution of indoor allergens to asthma is well documented, but links between socioeconomic disadvantage and indoor allergen levels are not clear. We investigated levels of cockroach allergens (Bla g 2) in a sample of 132 Dominican or African American low-income households with young children in northern Manhattan in New York City (40% were receiving public assistance) to determine whether the distribution of allergens is a function of housing deterioration. Deterioration was measured by the presence and number of physical housing problems (holes in the ceilings and walls, water damage, etc.). More than 50% of the sample had two or more types of housing dilapidation, and 67% of the sample reported cockroach sightings in their homes. Samples of dust were collected from kitchen and bedroom surfaces. We hypothesized that the greater the dilapidation, the higher the allergen levels, independent of income, sociocultural factors, and pest-control methods. In addition, we hypothesized that the homes of families characterized by frequent moves (23.5%) would have higher allergen levels than more stable families. Results showed significant positive associations between housing deterioration and allergen levels in kitchens, after adjusting for income and ethnicity, with independent effects of residential stability ($p < 0.05$). Bedroom allergen levels were associated with housing instability ($p < 0.01$) and ethnicity ($p < 0.01$). Findings demonstrated that indoor household allergen levels are related to degree of household disrepair, after adjusting for individual family attributes, suggesting that social-structural aspects of housing may be appropriate targets for public health interventions designed to reduce allergen exposure. **Key words:** childhood asthma, cockroach allergens, housing problems, inner-city minority populations. *Environ Health Perspect* 110(suppl 2):323–327 (2002).

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The importance of adequate housing for the maintenance of health has long been a topic of scientific and public health policy discussion (1). The world we construct for ourselves has profound effects upon our health, so the promotion of health and the prevention of disease may depend as much on buildings as on immunization (2). The physical aspects of housing serve the basic functions of protecting and sheltering people from the potentially harmful effects of the wider environment by providing such necessities as heat, light, cooking facilities, and proper waste disposal. At the same time, substandard housing can erode health by forcing people to live together in crowded, unsanitary, and dilapidated conditions, which may increase toxic exposures. Social aspects of the residential environment have also been implicated in positive health outcomes through the provision of safe shelter, kinship, and friendship bonds, and the sharing of resources and responsibilities. As with the physical aspects of housing, the social environment can undermine health (3). For example, housing stability/instability has been identified as one of the most important predictors of health at both the individual and community level (4). The history of

urban renewal in this country reflects, for the most part, a failure of communities to consider the consequences of physical and social residential disruption, with the result that whole communities have suffered displacement (5) and erosion of health (6).

Predictably, low-income neighborhoods carry the lion's share of substandard housing, imposing additional material and social burdens on those who are least able to manage them. Against this backdrop, however, careful inspection of low-income urban neighborhoods reveals tremendous variability in quality of life and health status indicators. Poor families are a heterogeneous group, as measured by variations in social and material living conditions (7–9), physical toxicants/irritants, and child health outcomes. Material hardships vary within income strata and may contribute to variability in health outcomes along physical as well as social pathways (10).

Childhood Asthma

Childhood asthma is an example of a serious public health problem associated with low-income, minority status (11,12), and characteristics of the home environment (13,14). Despite the generally high rates of asthma

among low-income minority children, most disadvantaged African American and Hispanic children do not develop asthma, suggesting marked variability in either exposures or vulnerabilities, or both, of individuals within these populations. The poverty paradigm is simply not an adequate explanation for high rates of childhood asthma and many other child health problems in this country (15). The search for other sources of variability in health and well-being among low-income urban populations must include the contribution of more proximal risk factors, both social and physical, including conditions that are potentially modifiable.

The Role of Indoor Allergens

The contribution of indoor allergens to childhood asthma has been well documented in recent years (16–20). Early childhood exposure appears to be a risk factor for development of allergy and asthma symptoms in people who are genetically predisposed (18), and in sensitized individuals, continued exposure appears to promote ongoing airway inflammation and hypersensitivity to other irritants. Specific allergen exposures depend upon environment as well as behavior, including length of time spent indoors (21). As a source of allergen exposure, the indoor environment is critical, based on evidence that individuals spend 87% of their time in enclosed buildings (22). In northeastern U.S. cities, cockroach, mouse, pet, house dust mite, and mold are among the most prevalent indoor allergens (23–25). Of these allergens, cockroach

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allergens have recently received great attention in the literature (24,25). Allergic sensitization to cockroaches has been related to the level of bedroom allergen exposure in children, with higher exposures among African American (26,27) and other low-income urban populations (28).

There is evidence that the distribution of cockroach allergens is influenced by characteristics of the built environment, such as building design and management (29), type of foundation (30), and type of dwelling (apartments vs. houses) (24). Goldstein and colleagues reported high levels of airborne cockroach allergen in Harlem apartments, with 85% of the homes of inner-city children with asthma having detectable cockroach allergen levels (23). Although several studies have investigated associations between type of housing and cockroach allergen levels (20,31), none have used a measure of housing deterioration.

This analysis explores links between cockroach allergen levels and selected housing characteristics, specifically evidence of amount and type of disrepair. An important point is that we are not focusing on extreme conditions but rather on the relatively widespread aspects of disrepair such as cracks in ceilings and walls, leaky pipes, unrepaired water damage, inadequate/irregular heating and electricity, and peeling paint—conditions that are regrettably part of the everyday lives of children who reside in underprivileged communities. The cockroach species of interest is *Blattella germanica* (German cockroach) because of its documented associations with asthma symptoms and its prevalence in the Northeastern United States (19,20). Because the residential environment has both social and physical dimensions, we have also considered the stability of the residential environment to explore how physical and social risk factors work together to determine allergen levels in house dust samples.

Methods

Study Population

This analysis is based on a larger cohort study from the Columbia University Children's Environmental Health Center, which began recruitment in January 1998. Study subjects are 76 Dominican and 56 African American women residing in northern Manhattan who delivered at Columbia Presbyterian Medical Center (CPMC), Harlem Hospital (HH), or satellite clinics. Women 18–35 years of age who registered at the OB/GYN clinics at CPMC and HH by the 20th week of pregnancy, who had resided in the area for at least 2 years, and who were free of diabetes, hypertension, or

known HIV were eligible. Informed consent was obtained from all participants. Because an end point of the larger study included the emergence of symptoms of childhood asthma as a function of exposure to specific airborne pollutants (such as environmental tobacco smoke) and allergens, current smokers were excluded from the study.

The target area for the Columbia University Children's Environmental Health Center includes the northern Manhattan communities of Central Harlem, Washington Heights/Inwood, and the South Bronx. Although these three contiguous communities are predominantly low income, they are distinct in racial/ethnic composition, culture, residential history, housing characteristics, resources, and problems. Perhaps more so than most other relatively poor communities, the residents are exposed to a disproportionate share of environmental hazards, ranging from those within the home and the housing itself to numerous neighborhood-based exposures, including physical environmental pollutants and aversive social conditions. It is estimated that 60–74% of the children in these communities live in fair to poor quality housing, compared with 38% citywide (32). However, despite the relative impoverishment and high level of risk characterizing the entire study area, there is striking variability within northern Manhattan with respect to physical and social aspects of the residential environment, belying the stereotype of a uniformly disadvantaged population. In Washington Heights, 67% of the population is Latino, predominately Dominican, and the poverty rate among New York City Dominicans is 45.7% (33). In Harlem, 69% of the population is African American and 22% Latino, and 29% of the Harlem residents are living in poverty (34). The residences of study participants were scattered throughout the target areas and did not cluster by building or block, so that the observations of housing deterioration were independent.

Measures

Demographic, residential, and lifestyle information for the cohort was collected by a 45-min questionnaire during the third trimester of pregnancy. The full questionnaire is based on an instrument used in prior studies and includes basic demographic information, residential history, health-related behaviors, and physical housing characteristics. Perceptions, behaviors, and knowledge regarding indoor pests were assessed by questions on the frequency of cockroach sightings inside the apartment, measures currently used within the apartment to control pests, and the respondent's general

understanding of pest behavior. Additional housing information included floor plan, apartment size, number of floors above street level, and the physical integrity of walls, floors, and ceilings.

Measurement and Analysis of Allergens

Dust samples were collected separately from the kitchen and beds of 132 pregnant women. This sampling occurred at the same time as the prenatal interview (i.e., during the third trimester). Dust was collected onto 70-mm cellulose filters (Whatman International, Maidstone, UK) with a canister vacuum cleaner (Eureka Mighty Mite, Bloomington, IN) and a modified collection nozzle (ALK, Inc., Horsholm, Denmark). In the kitchen we vacuumed exposed areas of the floor for 4 min. For the bed sample we vacuumed the pillows, upper half of the bed, and upper half of all bed layers for 4 min. Samples were returned to the laboratory for postweighing and then stored at -20°C . Dust samples were not sieved. Dust samples were extracted on a platform shaker for 1 hr at 30°C in phosphate-buffered saline with 0.05% Tween 20 solution. Cockroach allergen (Bla g 2) was assayed by sandwich enzyme-linked immunosorbent assay as previously described (Indoor Biotechnologies, Clywd, UK) (25).

Data Analysis

Mean Bla g 2 levels for kitchen and bedroom samples were examined as continuous variables. Because the distributions of mean Bla g 2 levels were highly skewed for kitchen (skewness = 2.838, standard error [SE] = 0.209) and bedroom (skewness = 5.555, SE = 0.210), the measure was log transformed. The resulting natural log transformation resulted in symmetrical distributions for both kitchen (skewness = 0.207, SE = 0.211) and bedroom (skewness = 0.884, SE = 0.213). Degree of housing disrepair was defined by the total number of adverse indoor housing problems; each condition was counted as present (1) or absent (0). The indicators of disrepair included holes in ceilings or walls, peeling or flaking paint, water damage, leaking pipes, and lack of gas or electricity in the past 6 months. Housing instability was treated as a dichotomous variable and scored "unstable" if the target family had moved within the past year and had resided at the previous residence for less than 2 years. Multiple linear regression was used to assess the magnitude of the contribution of housing disrepair and instability to the natural log of Bla g 2, after adjusting for possible confounding effects of income, ethnicity, and pest-control strategies.

Results

Table 1 presents the sociodemographic characteristics of the sample, as well as the distribution of housing disrepair problems. Antenatal interview data revealed that 68% of the sample reported the presence of roaches in their homes. Table 2 shows that the proportion of participants reporting roach sightings increased significantly with the number of physical housing problems (chi-square = 11.79, $p = 0.019$).

In addition to self-report interview data, we analyzed dust samples from the bedrooms and kitchens of participating households to obtain a more objective indicator of

roach infestation. Bla g 2 > 2 U/g was measured in 64% of the kitchens and 30% of the mothers' beds. Bla g 2 > 8 U/g was measured in 44% of the kitchens and 10% of the mothers' beds. Using Spearman's rho, the correlations between self-reported cockroach sightings and allergen levels in dust samples were highly significant for both bedroom ($r = 0.522, p < 0.001$) and kitchen ($r = 0.663, p < 0.001$).

Furthermore, associations between self-report and allergen dust levels were significant among Dominican women for bedroom ($p < 0.01$) and kitchen ($p < 0.001$), and African American women for bedroom ($p < 0.05$) and kitchen ($p < 0.001$). This suggests that there were no meaningful race/ethnic differences in the validity of maternal self-reports of cockroach sightings. Allergen levels were significantly higher in households reporting frequent roach sightings. The geometric mean (GM) and geometric standard deviation (GSD) level of Bla g 2 in kitchens of households with frequent sightings were 14.4 U/g (GSD = 10.4), respectively, versus 2.0 U/g (GSD = 6.4) for households with infrequent sightings ($F = 23.40, p < 0.001$), and the GM of Bla g 2 in beds of households with frequent sightings was 1.4 U/g (GSD = 5.8) versus 0.6 (GSD = 2.6) for households with infrequent sightings ($F = 6.98, p < 0.01$).

There was a significant correlation between kitchen and bedroom Bla g 2 levels within each home ($r = 0.50, p < 0.001$), and paired t -test for households with both

kitchen and bedroom measurements ($n = 114$) revealed significantly higher mean Bla g 2 levels in the kitchens compared with bedrooms ($t_{(114)} = 9.927; p < 0.001$).

Figures 1 and 2 show the increase in mean Bla g 2 levels as a function of physical housing problems for kitchens and bedrooms, respectively. Unadjusted mean analyses showed that this trend was of borderline significance for kitchens ($F = 2.07, p = 0.09$) and bedrooms ($F = 2.06, p = 0.09$). Unadjusted median analyses showed that the trend was statistically significant for kitchens (chi-square = 11.00, $p = 0.03$), but not for bedrooms (chi-square = 1.89, $p =$ not significant). Multiple regression analyses were used to elucidate these trends.

Separate multiple regressions for kitchen and bedroom were used to predict the estimated value of the natural log of Bla g 2 for a set of independent variables, after adjusting for income and ethnicity. Because the use of pest-control measures are associated with overall cockroach population levels, we also adjusted for the number of pest-control measures used in each home in each model. In addition to the measure of housing disrepair, the independent variables included a measure of housing instability to determine if allergen levels were associated with the social integrity of the housing, independent of its physical integrity. The rationale was that short-term housing used by transient or highly mobile individuals would tend to be characterized by poorer-quality management/upkeep and hence more likely to be cockroach infested. Other possible determinants of allergen levels included in the models were structural parameters (floor lived on, number of floors in the building, presence of a basement, or restaurant nearby). Correlational analyses (not shown) were used to examine the possible role of various cleaning methods (mop, broom, vacuum) and the presence of pet food and other open food sources (factors that might be associated with the level of allergens), but no significant associations warranted inclusion of these factors in the models.

Table 3 shows that, after adjusting for the effects of income, ethnicity, and pest-control measures (Model I), the degree of disrepair and housing instability were both significantly associated with Bla g 2 levels in the kitchen (Model II). Cleaning methods and other possible contributing factors were not significantly associated with Bla g 2 levels in the kitchen. Table 4 shows the results of the bedroom analysis; again, cleaning methods were not a significant determinant of Bla g 2 levels. After adjustment for income, ethnicity, and pest-control measures (Model I), degree of housing deterioration was of borderline significance

Table 1. Sociodemographic characteristics of the sample.

Characteristic	Percentage (%)	Number (n = 132)
Maternal age (years)		
<20	14.4	19
20–24	49.2	65
25–30	18.1	24
>30	18.3	24
Maternal education		
<High school	30.9	37
High school degree	48.4	52
>High school	20.7	43
Ethnic background		
Dominican	57.6	76
African American	42.4	56
Married	18.3	24
Annual household income		
<\$10,000	52.8	65
>\$10,000 ^a	47.2	67
Public assistance	40.0	52
Unstable housing ^b	23.5	31
Physical housing problems		
Leaking pipes	21.5	28
Holes in ceilings or walls	37.7	49
Unrepaired water damage	29.3	27
Interrupted heat or electrical service ^c	13.6	18
Paint chips or peeling paint	47.2	60

^aOnly three families reported income above \$30,000, and these fell between \$30,000 and \$50,000. They were included in the near-poor category. ^bDichotomous variable defined by both of the following conditions: less than 1 year in present residence and less than 2 years in previous residence. ^cDefined as one or more utility cut-offs in the past 6 months.

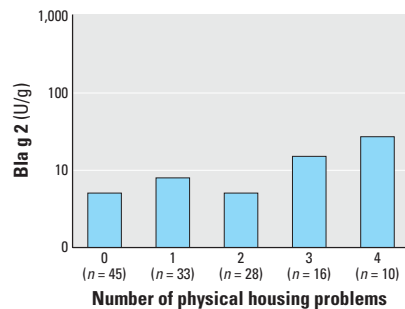


Figure 1. Geometric mean and geometric standard deviation of cockroach allergen in kitchens as a function of physical housing problems (y-axis is displayed on the log₁₀ scale).

Table 2. Proportion of frequent cockroach sightings by level of housing problems.^a

Level of housing problems	Frequent cockroach sightings (%)	Number (n = 132)
0	15.6	45
1	30.3	33
2	22.2	27
3	37.5	16
4 or more	63.6	11

^aChi-square = 11.79, $p = 0.019$.

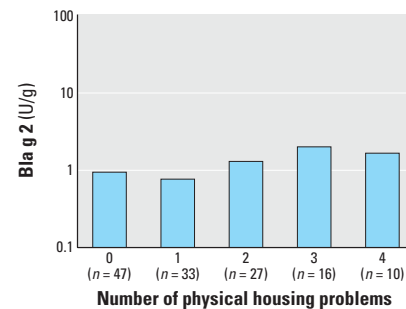


Figure 2. Geometric mean and geometric standard deviation of cockroach allergen as a function of physical housing problems (y-axis is displayed on the log₁₀ scale).

Table 3. Multiple linear regression model expressing allergen level (Bla g 2) in the kitchen as a linear function of number of physical housing problems (dilapidation) and housing instability, adjusted for income and ethnicity.

Predictor	Model I ($r^2 = 0.21$)				Model II ($r^2 = 0.29$)			
	Coefficient		95% CI for β		Coefficient		95% CI for β	
	β	SE	Lower bound	Upper bound	β	SE	Lower bound	Upper bound
Household income 1 = very poor 0 = near poor	-0.249	0.415	-0.571	1.069	-0.410	0.408	-1.216	0.397
Ethnicity 1 = African American 0 = Dominican	0.376	0.434	-0.482	1.234	0.497	0.428	-0.350	1.343
Pest-control measures (range = 1–7) ^a	0.451	0.271	-0.086	0.987	0.304	0.270	-0.220	0.847
Housing instability ^b 1 = unstable 0 = stable					1.161	0.482	0.208	2.115
Total number of physical housing problems ^c (range = 0–5)					0.320	0.154	0.016	0.624

CI, confidence interval.

^aDefined as number of pest-control measures used in the household, including pesticides sprayed by exterminator, can sprays, insect bomb, sticky traps, bait traps, boric acid, and gel.^bDichotomous variable defined by both of the following conditions: less than 1 year in present residence and less than 2 years in previous residence. ^cFive-item scale including leaking pipes, holes in ceilings/walls, peeling paint/paint chips, unrepaired water damage, interruptions in heat or electricity.**Table 4.** Multiple linear regression model expressing allergen level (Bla g 2) in the bedroom as a linear function of number of physical housing problems (dilapidation) and housing instability, adjusted for income and ethnicity.

Predictor	Model I ($r^2 = 0.21$)				Model II ($r^2 = 0.29$)			
	Coefficient		95% CI for B		Coefficient		95% CI for B	
	B	SE	Lower bound	Upper bound	B	SE	Lower bound	Upper bound
Household income 1 = very poor 0 = near poor	0.564	0.257	0.056	1.073	0.396	0.250	-0.098	0.892
Ethnicity 1 = African American 0 = Dominican	0.818	0.272	0.280	1.356	0.919	0.261	0.402	1.437
Pest-control measures (range = 1–7) ^a	0.551	0.174	0.207	0.896	0.485	0.168	0.152	0.818
Housing instability ^b 1 = unstable 0 = stable					1.002	0.285	0.438	1.566
Total number of physical housing problems ^c (range = 0–5)					0.153	0.094	-0.032	0.338

^aDefined as number of pest control measures used in the household, including: pesticides sprayed by exterminator, can sprays, insect bomb, sticky traps, bait traps, boric acid, and gel.^bDichotomous variable defined by both of the following conditions: less than one year in present residence and less than 2 years in previous residence. ^cFive-item scale including leaking pipes, holes in ceilings/walls, peeling paint/paint chips, unrepaired water damage, no heat or electricity.

(Model II), and this may be because the impact of deteriorated housing (cracks, water damage, leaky pipes) is more evident in the kitchen, where food sources attract the cockroach population. Housing instability was again a strong predictor of Bla g 2 levels (Model II).

Discussion

The cockroach allergens levels found in this study in the homes of children living in northern Manhattan are comparable to levels found by other studies. For example, a study in Wilmington, Delaware, reported that 37% (68/186) of the homes had Bla g 2 levels >2 U/g, a proposed threshold for allergic sensitization (19). The National Cooperative Inner-City Asthma Study (NCICAS) reported 50% (239/476) of children's homes had Bla g 1 > 8 U/g (20). The Delaware study contained urban and suburban homes,

whereas the NCICAS study concentrated on inner-city homes and is thus most similar to our study with regard to types of housing.

More important, the finding of a statistically significant association between degree of housing disrepair and cockroach allergen level, independent of income, suggests there may be social-structural factors contributing to the disproportionately high exposure levels in some populations. This is important because individual families may not have the resources or even the responsibility to redress such conditions—conditions largely controlled by landlords, managing agents, and city agencies. If the cockroach population in apartments, buildings, or even whole city blocks is at least partly a function of physical conditions and/or failure to maintain the built environment, and if the use of common pest-control measures does not significantly mitigate this association, then perhaps

more structural, rather than individual, approaches to public health interventions are needed to effectively reduce exposures (35).

It is important to understand that the quality of the built environment (and its potential to influence health) is partly determined by public policy, as in the case of urban renewal. In New York City, inadequate city code enforcement and repair of city properties have led to the systematic deterioration of the housing stock and, in some cases, entire neighborhoods. An unintended consequence of housing neglect and poorly planned renewal efforts has been the dislocation of large groups of people, resulting in further community instability and the disruption of social networks. These are the kinds of social processes/forces that may lead to specific environmental exposures that underlie associations between housing and health.

Our finding that there may be either ethnic or neighborhood differences in cockroach exposure levels deserves further exploration in a larger sample. The confounding of race/ethnicity and place of residence has plagued the literature (36,37) and may mask important findings related to the distinct characteristics of the built environment in various geographic areas. Interestingly, the study of asthma rates presents a similar challenge, at least partly because of the ethnicity/residential confound. For example, a recent study of geographic variations in pediatric asthma rates, sampled by ethnicity and socioeconomic level, showed considerable variation in prevalence of severe asthma (persistent wheeze) by ethnicity, socioeconomic levels and geography (38). After adjusting for level of community disadvantage (overcrowding, percent unemployed, percent without a car, and percent over 65 years of age), ethnic differences in prevalence of severe asthma disappeared, but some geographic variation remained. Although the persistent geographic variation in severe asthma rates may be due, in part, to the poor management of asthma in poorer areas, Duran-Tauleria and Rona suggest that material and behavioral characteristics associated with poverty, such as parental smoking, air pollution, housing conditions, and allergens, may contribute to the disparities (38).

As seen above, the quality of the built environment is closely linked to residential stability and population movement. In this study, the impact of the residential instability factor on Bla g 2 levels also deserves further study, as it can be viewed as a characteristic of the housing (i.e., apartments with high turnover tend to be less well maintained) or the families themselves. At the individual level, extreme residential mobility constitutes a barrier to the development of informal local friendship networks, kinship bonds, and local organizational ties and is associated with homelessness and adverse health outcomes for individuals and families. At the community level, social fragmentation and the loss of social cohesion, even more than standard sociologic variables such as poverty and ethnic/racial composition, have been linked to high rates of crime and illness (39). These are conditions that work against the maintenance of high-quality housing and may overwhelm individual efforts to maintain such standards.

This leads to our consideration of the role of housing as a potential agent of change or a focus of intervention aimed to reduce the harmful effects of environmental pollutants. Can interventions to correct the inadequacies of the residential environment reduce the prevalence of childhood asthma?

Some parameters are policy sensitive, such as where to build a housing project, enforcement of municipal codes, rehabilitation of existing residential units, and dispersal of the disadvantaged, yet we do not know if such interventions will improve child health. For example, residential management of public housing may increase housing stability, tenant buyouts may increase home ownership and commitment, and rehabilitation of existing residential units and strict code enforcement may prevent physical deterioration. However, the links between such community-level interventions, reduction in exposure to toxicants, and real child health improvements at both the individual and the group level remain to be studied.

REFERENCES AND NOTES

- Workshop on Housing and Health: Interrelationship and Community Impact. New York:New York Academy of Medicine, 1989.
- Anonymous. Housing and health: interrelationship and community impact. *Bull N Y Acad Med* 66(5):379-591 (1996).
- Dunn JR, Hayes MV. Identifying social pathways for health inequities. The role of housing. *Ann N Y Acad Sci* 896:399-402 (1999).
- Fullilove MT. Promoting social cohesion to improve health. *J Am Med Womens Assoc* 53(2):72-76 (1998).
- Fullilove MT. Psychiatric implications of displacement: contributions from the psychology of place. *Am J Psych* 153:1516-1523 (1996).
- Wallace R, Wallace D. Origins of public health collapse in New York City: the dynamics of planned shrinkage, contagious urban decay and social disintegration. *Bull N Y Acad Med* 66(5):351-434 (1990).
- Reeb K, Graham A, Zyzanski S, Kitson G. Prediction of low birthweight and complicated labor in urban black women: a biopsychosocial perspective. *Soc Sci Med* 25(12):1321-1327 (1987).
- Stokols D. Establishing and maintaining healthy environments toward a social ecology of health promotion. *Am Psychol* 47(1):6-22 (1992).
- Manfredi C, Lacey L, Warnecke R, Buis M. Smoking-related behavior, beliefs and social environment of young black women in subsidized public housing in Chicago. *Am J Public Health* 82:267-272 (1992).
- Mayer S, Jencks C. Poverty and the distribution of material hardship. *J Hum Resour* 24(1):88-113 (1989).
- Newacheck PW, Halfon N. Prevalence, impact and trends in childhood disability due to asthma. *Arch Pediatr Adolesc Med* 154(3):287-293 (2000).
- Littlejohns P, Macdonald LD. The relationship between severe asthma and social class. *Respir Med* 87(2):139-143 (1993).
- Carr W, Zeitel L, Weiss K. Variations in asthma hospitalizations and deaths in New York City. *Am J Public Health* 82(1):59-65 (1992).
- Claudio L. Reaching out to New York neighborhoods. *Environ Health Perspect* 108(10):A450-A451 (2000).
- Rowley DL, Hogue CJ, Blackmore CA, Ferre CD, Hatfield-Timajchyk K, Branch P, Atrash HK. Preterm delivery among African-American women: a research strategy. *Am J Prev Med* 9(suppl 6):1-6 (1993).
- Burrows B, Martinez FD, Halonen M, Barbee RA, Cline MG. Association of asthma with serum IgE levels and skin-test reactivity to allergens. *N Engl J Med* 320:271-277 (1989).
- Platts-Mills TAE. How environment affects patients with allergic diseases: indoor allergens and asthma. *Ann Allergy* 72:381-384 (1994).
- Sporik R, Holgate ST, Platts-Mills TAE, Cogswell JJ. Exposure to house dust mite allergens (Der p I) and the development of asthma in childhood: a prospective study. *N Engl J Med* 323:502-507 (1990).
- Gelber LE, Seltzer LH, Bouzoukis JK, Pollart SM, Chapman MD, Platts-Mills TAE. Sensitization and exposure to indoor allergens as risk factors for asthma among patients presenting to hospital. *Am Rev Respir Dis* 147:573-578 (1993).
- Rosenstreich DL, Eggleston P, Kattan M, Baker D, Slavin RG, Gergen P, Mitchell H, McNiff-Mortimer K, Lynn H, Ownby D, et al. The role of cockroach allergy and exposure to cockroach allergen in causing morbidity among inner-city children with asthma. *N Engl J Med* 336:1356-1363 (1997).
- Sexton K, Ryan PB. Assessment of human exposure to air pollution: methods, measurements and models. In: *Air Pollution, the Automobile and Public Health* (Watson AY, Bates RR, Kennedy D, eds). Health Effects Institute. Washington, DC:National Academy Press, 1988:207-238.
- Klepeis NE, Nelson WC, Ott WR, Robinson JP, Tsang AM, Switzer P, Behar JV, Hern SC, Engelmann WH. The National Human Activity Pattern Survey (NHAPS): a resource for assessing exposure to environmental pollutants. *J Expo Anal Environ Epidemiol* 11(3):231-252 (2001).
- Goldstein IF, Reed CE, Swanson MC, Jacobson J. Aeroallergens in New York inner city apartments of asthmatics. *Adv Aerobiol* 51:133-138 (1987).
- Chew GL, Higgins KM, Gold DR, Muilenberg ML, Burge HA. Monthly measurements of indoor allergens and the influence of housing type in a northeastern US city. *Allergy* 54(10):1058-1066 (1999).
- Pollart SM, Smith TF, Morris EC, Gelber LE, Platts-Mills TAE, Chapman MD. Environmental exposure to cockroach allergens: analysis with monoclonal antibody-based enzyme immunoassays. *J Allergy Clin Immunol* 87:505-510 (1991).
- Sarpong SB, Hamilton RG, Eggleston PA, Adkinson FN. Socioeconomic status and race as risk factors for cockroach allergen exposure and sensitization in children with asthma. *J Allergy Clin Immunol* 97:1393-1401 (1996).
- Kitch BT, Chew G, Burge HA, Muilenberg ML, Weiss ST, Platts-Mills TA, O'Connor G, Gold DR. Socioeconomic predictors of high allergen levels in homes in the greater Boston area. *Environ Health Perspect* 108(4):301-307 (2000).
- Pollart SM, Chapman MD, Fiocco CP, Rose G, Platts-Mills TAE. Epidemiology of acute asthma: IgE antibodies to common inhalant allergens as a risk factor for emergency room visits. *J Allergy Clin Immunol* 83:875-882 (1989).
- Jones AP. Asthma and domestic air quality. *Social Science Med* 47(6):755-764 (1998).
- Garrett MH, Hooper MA, Hooper BM, Abramson MJ. Respiratory symptoms in children and indoor exposure to nitrogen dioxide and gas stoves. *Am J Respir Crit Care Med* 158(3):891-895 (1998).
- Chew GL, Burge HA, Dockery DW, Muilenberg ML, Weiss ST, Gold DR. Limitations of a home characteristics questionnaire as a predictor of indoor allergen levels. *Am J Respir Crit Care Med* 157(5):1536-1541 (1998).
- Citizen's Committee for the Children of New York: Keeping Track of New York City's Children. New York:Citizen's Committee for the Children, 1995.
- Hernandez R, Rivera-Batiz F. Dominican New Yorkers: A Socioeconomic Profile. Dominican Research Monographs. New York:The CUNY Dominican Studies Institute, 1997.
- Garfield RM, Abramson DME. Washington Heights/Inwood: The Health of a Community. New York, NY:The Health of the Public Program at Columbia University, 1994.
- Geronimus AT. To mitigate, resist or undo: addressing structural influences on the health of urban populations. *Am J Public Health* 90(6):867-872 (2000).
- Mielch A, Reitmeir P, Wjst M. Severity of childhood asthma by socioeconomic status. *Int J Epidemiol* 25(2):388-393 (1996).
- Strachan DP, Golding J, Anderson HR. Regional variations in wheezing illness in British children: effect of migration in early childhood. *J Epidemiol Commun Health* 44(3):231-236 (1990).
- Duran-Tauleria E, Rona RJ. Geographic and socioeconomic variation in the prevalence of asthma symptoms in English and Scottish children. *Thorax* 54(6):476-481 (1999).
- Sampson RJ, Raudenbush SW, Earls F. Neighborhoods and violent crime: a multi-level study of collective efficacy. *Science* 277:918-924 (1997).