SUPPLEMENT ARTICLE

Indoor Environmental Exposures Among Children With Asthma Seen in an Urban Emergency Department

Stephen J. Teach, MD, MPH[a,d], Ellen F. Crain, MD, PhD[b], Deborah M. Quint, BA[c], Michelle L. Hylan, BA[c], Jill G. Joseph, MD, PhD[d]

[a]Division of Emergency Medicine and [d]Center for Health Services and Community Research, Children's Research Institute, Children's National Medical Center, George Washington University School of Medicine and Health Sciences, Washington, DC; [b]Division of Emergency Medicine, Department of Pediatrics, Jacobi Medical Center, Albert Einstein College of Medicine, Bronx, New York; [c]Center for Health Services and Community Research, Children's Research Institute, Children's National Medical Center, Washington, DC

Financial Disclosure: Dr Teach serves on the speakers' bureau for AstraZenca. The other authors have indicated they have no financial relationships relevant to this article to disclose.

ABSTRACT

BACKGROUND. Current guidelines for asthma management emphasize the control of environmental irritants and allergens within the home. Understanding the prevalence of indoor home exposures within such a population may be important for any emergency department (ED) program that seeks to improve the quality of its asthma care and patient education.

OBJECTIVE. We sought to determine the prevalence of indoor home exposures in a cohort of children with moderate to severe asthma who were treated in an urban pediatric ED and to correlate these exposures with household income, prior asthma morbidity, health care utilization, and quality of life (QoL).

METHODS. We enrolled a cohort of children with chronic asthma who were 12 months through 17 years of age and who had at least one other unscheduled visit for asthma within the previous 6 months. Trained research assistants interviewed the children's parent or guardian regarding the prevalence of home exposures to environmental tobacco smoke (ETS) and common allergens. In addition, data were collected on each patient's prior asthma history, morbidity, health care utilization, medication use, and QoL.

RESULTS. Of the 488 eligible children enrolled, 60.0% were <6 years of age, 63.9% were male, 85.9% were black, 68.4% were publicly insured, and 51.8% had >3 ED visits in the previous 12 months. Home exposure to ETS and potential allergens was high. Exposure to cockroach allergen was significantly associated with household income. Coexistence of exposures was common: significantly more patients reporting ETS exposure also reported exposure to cockroach allergen and mold than those not reporting ETS exposure. Poorer QoL was significantly associated with cockroach exposure, although this effect was limited to those also exposed to ETS. Higher rates of unscheduled health care utilization and persistent asthma symptoms were not associated with exposures.

CONCLUSION. Additional investigation is necessary to clarify the role of exposure-avoidance measures as a component of ED-based interventions for asthma care.

www.pediatrics.org/cgi/doi/10.1542/peds.2005-2000M

doi:10.1542/peds.2005-2000M

Ms Hylan's current address is Genzyme Corp, 500 Kendall St, Cambridge, MA 02142.

Dr Joseph's current address is Department of Pediatrics, University of California, Davis, 2516 Stockton Blvd, Sacramento, CA 95817.

Key Words
asthma management, environmental exposure, indoor allergens

Abbreviations
ETS— environmental tobacco smoke
NHLBI—National Heart, Lung, and Blood Institute
ED— emergency department
CNMC—Children's National Medical Center
QoL— quality of life
OR— odds ratio
CI— confidence interval
RR—relative risk
NCICAS—National Cooperative Inner-City Asthma Study

Accepted for publication Dec 6, 2005

Address correspondence to Stephen J. Teach, MD, MPH, Division of Emergency Medicine, Children's National Medical Center, 111 Michigan Ave NW, Washington, DC 20010. E-mail: steach@cnmc.org

A RECENT REPORT from the Institute of Medicine[1] found sufficient evidence for a causal relationship between exposure to environmental tobacco smoke (ETS) and exacerbations of asthma. Evidence is strong that exposure to ETS affects the morbidity and health care utilization of children with asthma.[2–4] Indoor exposures to common allergens are also risk factors for the exacerbation of asthma.[5–8] The same Institute of Medicine report found sufficient evidence for a causal relationship between indoor exposure to allergens produced by cockroaches, cats, dogs, house dust mites, and mold and worsening of asthma.

Current guidelines for asthma management from the National Heart, Lung, and Blood Institute (NHLBI)[9] and the American Academy of Allergy, Asthma and Immunology[10] therefore emphasize the control of exposure to ETS and indoor allergens as a crucial component of asthma management within a coordinated program of longitudinal care with a primary care provider. Unfortunately, however, disadvantaged urban minority children with asthma seek much of their care in emergency departments (EDs).[11–13] In fact, for many inner-city children, the ED is the primary source of their asthma care,[14] yet little is known about the role that the urban ED can play in assessing and reducing environmental exposures. Understanding the nature of indoor home exposures within a population that relies heavily on the ED for asthma care may be important for improving ED asthma care.

Our objective with this analysis, therefore, is to describe the prevalence of parental report of home exposure to ETS and potential allergens in a cohort of children with moderate to severe asthma and a history of high ED recidivism for asthma. We also explore associations of exposures with household income and whether indoor environmental exposures are associated with higher asthma health care utilization and recent asthma morbidity.

METHODS

Data analyzed here were collected from a cohort of patients prospectively recruited as part of a randomized clinical trial that enrolled children presenting for acute asthma care in the ED at Children's National Medical Center (CNMC) in Washington, DC, from April 2002 until January 2004. CNMC is an urban, tertiary care pediatric medical center with an ED volume of 72 778 visits in 2003. Of these visits, 4482 (6.1%) included a primary discharge diagnosis of asthma among patients aged 12 months to 17 years, inclusive.

This study was approved by the CNMC Institutional Review Board. The parent or guardian provided informed consent, and participants >6 years old provided assent.

Inclusion Criteria

Trained research assistants recruited subjects among those who presented with respiratory complaints. Inclusion criteria included all of the following: (1) age between 12 months and 17 years, inclusive; (2) prior physician-diagnosed asthma; (3) ≥1 other unscheduled visit for asthma in the previous 6 months and/or ≥1 hospitalization for asthma in the previous 12 months; (4) a parent or guardian available for interview; (5) residence in Washington, DC, or a contiguous Maryland county; and (6) required ≥3 doses of nebulized albuterol in the ED at the time of enrollment.

Exclusion Criteria

Exclusion criteria included (1) significant medical comorbidities affecting the cardiorespiratory system; (2) a visit to an allergist or pulmonologist in the previous 6 months; (3) ≥2 of the following: a current written asthma medical action plan, current use of >1 controller medication, or a scheduled visit for asthma care with the primary care provider in the previous 2 weeks; (4) enrollment in another asthma research study; (5) unavailability for telephone follow-up; or (6) primary language other than English or Spanish.

Data Collection

The research assistants administered a baseline questionnaire to the child's parent or guardian. This measure assessed the presence of ETS and multiple potential indoor allergens within the child's principal residence. It also assessed patient and family demographics, past asthma history, asthma severity classification by the criteria of the NHLBI,[9] asthma quality of life (QoL), and history of health care utilization for asthma. QoL was scored through the use of a measure developed and validated for pediatric asthma.[15,16]

Exposure to ETS and potential allergens was based on the caregiver report. ETS exposure was defined as someone currently living in the child's home who smokes cigarettes. Cockroach exposure was defined by the caregiver report of seeing cockroaches in the home in the previous month. Mold exposure was defined as the caregiver noticing mold or dampness in the home in the previous month. Dust mite exposure was defined by the presence of a carpet in the room where the child sleeps and/or stuffed animals on the child's bed. In addition, we noted if a dog or cat lived in the home.

Statistical Analysis

Descriptive analyses estimated the relative frequency of participants according to demographic, socioeconomic, and clinical characteristics. The adjusted odds ratios (ORs) with 95% confidence intervals (CIs) for environmental exposures were then estimated by using multiple logistic regression with covariables including age, gender, and race/ethnicity and with stratification for house-

hold income and then ETS exposure. These methods were also used to estimate the adjusted relative risks (RRs) of greater than the median number of unscheduled medical visits, of persistent asthma symptoms, and of less than median scores for 3 indicators of QoL. For the latter analyses, adjustment was made for the sociodemographic variables listed above as well as for medical care indicators and season of enrollment. Finally, posthoc secondary analysis was performed to examine the association between ETS exposure and allergen exposure.

RESULTS

The research assistants screened 2791 patients with a chief complaint of respiratory symptoms. Of these, 521 (18.7%) were eligible for enrollment and 490 (94.0%) were enrolled. Two enrolled patients were subsequently excluded for enrollment violations, which left 488 patients available for analysis. Patients were enrolled in the following windows: 65% between 8 AM and 4 PM, 18% between 4 PM and midnight, and 17% between midnight and 8 AM. Ten percent of the patients were enrolled on a Saturday or Sunday.

As shown in Table 1, patients were overwhelmingly minority and low income. Just under 25% reported using inhaled corticosteroid medication in the past month. More than half had visited the ED >3 times in the past year, and 30.3% had been hospitalized for asthma in the previous year. Despite this, 40.6% of the children were classified as having mild intermittent asthma according to NHLBI criteria.[9]

Reported prevalence of exposure to ETS and potential allergens in the home was high in this cohort of patients, as shown in Table 2. Exposure to cockroach allergen was significantly higher in lower-income households, whereas exposure to ETS, dog/cat, mold, and dust mites did not differ between the highest and lowest income levels.

The prevalence of combined indoor exposure to ETS and potential allergens is shown in Table 3. Exposure to ETS was significantly associated with exposure to both cockroach allergen and mold (cockroach: 34.0% vs 23.7% [OR: 1.66; 95% CI: 1.05–2.60]; mold: 26.3% vs 15.9% [OR: 1.89; 95% CI: 1.15–3.11]).

Table 4 shows the relationship of specific environmental exposures and ETS to measures of asthma morbidity and QoL. In general, exposures to potential allergens, with or without ETS, were unrelated to these measures. The exception is that cockroach exposure in households with ETS may increase children's functional limitations and nighttime symptoms. We note, however, the large number of comparisons and relatively small number of significant findings.

TABLE 1 Demographic Characteristics of 488 Study Participants

Variable	*n* (%)
Age, y	
1–5	293 (60.0)
6–10	128 (26.2)
11–15	57 (11.7)
≥16	10 (2.1)
Male	312 (63.9)
Race/ethnicity	
Black	419 (85.9)
Hispanic	46 (9.4)
Insurance type	
Public	333 (68.4)
Private	136 (27.9)
Uninsured	18 (3.7)
Household income	
≤$10 000	101 (22.4)
$10 001–$30 000	156 (34.7)
>$30 000	193 (42.9)
Inhaled corticosteroid use in month before enrollment	118 (24.2)
Leukotriene antagonist use in month before enrollment	51 (10.5)
ED visits for asthma in previous 12 mo (including enrollment visit)	
1	39 (8.0)
2–3	196 (40.2)
≥4	253 (51.8)
Other unscheduled asthma visits in previous 12 mo	
0	194 (39.9)
1–2	130 (26.8)
≥3	162 (33.3)
Hospitalizations for asthma in previous 12 mo	
0	340 (69.7)
1–2	126 (25.8)
≥3	22 (4.5)
Month of enrollment	
December to February	113 (23.2)
March to May	121 (24.8)
June to August	88 (18.0)
September to November	166 (34.0)
NHLBI asthma-severity classification	
Severe persistent	78 (16.0)
Moderate persistent	70 (14.3)
Mild persistent	142 (29.1)
Mild intermittent	198 (40.6)

DISCUSSION

These data demonstrate a high level of reported home exposure to ETS and common allergens among high-morbidity children with asthma recruited from an urban pediatric ED. However, there was no consistent relationship of any environmental exposure to multiple measures of asthma morbidity, including health care utilization, persistent asthma symptoms, or QoL. Only in the presence of ETS did cockroach exposure seem to adversely affect QoL.

ETS exposure in our cohort is higher than that found in other studies of high-morbidity asthmatics. Two reports from the National Cooperative Inner-City Asthma Study (NCICAS) found that between 48% and 59% of children in their cohorts lived in a home with a smok-

TABLE 2 **Prevalence of Home Exposure to ETS and Allergens With Odds of Exposure Stratified According to Household Income and Adjusted for Age, Gender, Race, and Ethnicity**

Potential Exposure in Home	Unadjusted Overall Prevalence ($n = 450$), %[a]	Household Income ≤$10 000 ($n = 101$)		Household Income $10 001–30 000 ($n = 156$)		Household Income >$30 000 ($n = 193$), Adjusted Prevalence, %[b]
		Adjusted Prevalence, %	Adjusted OR (95% CI)	Adjusted Prevalence, %	Adjusted OR (95% CI)	
ETS	63.3	72.2	1.63 (0.96–2.77)	60.2	0.95 (0.61–1.48)	61.4
Cockroach	31.2	42.4	2.60 (1.52–4.46)	34.6	1.87 (1.15–3.03)	22.1
Dog and/or cat	18.7	14.6	0.68 (0.35–1.32)	16.2	0.77 (0.44–1.34)	20.1
Visible mold or musty smell in home	22.8	16.9	0.60 (0.32–1.12)	23.0	0.89 (0.54–1.46)	25.2
Dust mites in child's bedroom	79.1	76.3	0.57 (0.31–1.05)	74.7	0.52 (0.30–0.90)	84.9

[a] Household income information was missing for 38 patients.
[b] Reference group.

TABLE 3 **Prevalence of Exposure to Potential Allergens in the Home Stratified According to Exposure to ETS With Adjustment for Age, Gender, Race, Ethnicity, and Income Level**

Potential Exposure in Home	Adjusted Prevalence, %		Adjusted OR (95% CI)
	Smoker Living in Home ($n = 310$)	No Smoker Living in Home ($n = 178$)	
Cockroach[a]	34.0	23.7	1.66 (1.05–2.60)
Dog and/or cat[a]	20.1	13.2	1.65 (0.96–2.82)
Visible mold or musty smell in home[b]	26.3	15.9	1.89 (1.15–3.11)
Dust mites in child's bedroom	77.4	84.0	0.66 (0.39–1.09)

[a] Data are missing for 1 patient.
[b] Data are missing for 3 patients.

er.[11,19] These rates are also higher than national data, showing that ~43% of all US children aged 2 months to 11 years live in a home with at least 1 smoker.[17] The rate of ETS exposure in our cohort is also much higher than the 25.7% of black adults in the District of Columbia who reported current smoking in 2003,[18] no doubt at least partly reflecting the presence of multiple adults in the homes.

Reports of the rates of exposure to mold, cockroach allergen, and furry pets in our cohort are lower than those found in the NCICAS.[19] In that national sample of inner-city children with moderate to severe asthma, 57.8% reported problems with cockroaches; 27.8% reported furry pets currently living in the home; and 45.4% of caregivers reported water, dampness, or water leaks. The NCICAS also reported lower household income than our cohort; thus, some of the difference in reported exposures may be related to socioeconomic status and the quality and type of housing. Perhaps more importantly, the NCICAS reported exposures in the previous 12 months, whereas we asked only about the previous month. Our data were consistent with others' findings that cockroach exposure and sensitization are associated with lower socioeconomic status [20,21] and that cat and dust mite allergen exposure seems to be less common in high-poverty areas.[21]

An unexpected finding in secondary analysis revealed a significant relationship between exposure to ETS and exposure to cockroach allergen and mold. These associations persisted after controlling for household income and therefore are not exclusively socioeconomic effects. This finding merits additional prospective evaluation.

Although the documentation of exposure is important, a crucial issue is whether attempts to mitigate these exposures will improve outcomes in disadvantaged urban children living with asthma. Previous studies suggest that the issue is complex. For example, the use of allergen-barrier mattress pads and pillow covers to reduce exposure to dust mites has shown inconsistent results.[22–26] In addition, reducing cockroach allergen in urban homes is challenging and in some studies has produced no apparent clinical benefit.[22,27] However, a recent intervention aimed at reducing exposure to multiple indoor allergens and ETS has produced a significant and sustained decrease in asthma symptoms.[28] This multifaceted intervention addressed those specific exposures to which each individual child was allergic. Although the study enrolled inner-city children with asthma, it did not recruit patients solely from the ED.

Within our population, the association of exposure to ETS and individual potential indoor allergens to health care utilization and morbidity was neither statistically nor clinically significant. However, exposure to both ETS and cockroach allergen was associated with 2 measures

TABLE 4 Adjusted RR of Total Unscheduled Visits for Asthma Care Above the Population Median, Persistent Asthma Symptoms, and QoL Score Below the Population Median, With and Without Stratification According to Exposure to ETS

Exposure	Entire Group ($n = 488$), RR (95% CI)			Smoker in Home ($n = 310$), RR (95% CI)			No Smoker in Home ($n = 178$), RR (95% CI)		
	Total Unscheduled Visits Above Median	Persistent Asthma Symptoms	QoL Score Below Median[a]	Total Unscheduled Visits Above Median	Persistent Asthma Symptoms	QoL Score Below Median[a]	Total Unscheduled Visits Above Median	Persistent Asthma Symptoms	QoL Score Below Median[a]
ETS	0.96 (0.80–1.15)	1.01 (0.86–1.19)	0.98 (0.83–1.15)	—	—	—	—	—	—
			0.96 (0.83–1.11)						
			1.07 (0.89–1.29)						
Cockroach	1.10 (0.91–1.34)	1.05 (0.89–1.24)	1.13 (0.97–1.33)	1.21 (0.95–1.54)	1.11 (0.91–1.36)	1.26 (1.03–1.53)	0.96 (0.66–1.38)	1.01 (0.74–1.38)	0.94 (0.70–1.28)
			1.16 (1.01–1.34)			1.18 (0.98–1.41)			1.15 (0.91–1.46)
			1.23 (1.02–1.47)			1.28 (1.03–1.59)			1.13 (0.81–1.58)
Dog and/or Cat	1.22 (0.98–1.53)	0.92 (0.75–1.13)	0.94 (0.76–1.15)	1.21 (0.92–1.58)	0.92 (0.72–1.16)	0.94 (0.73–1.20)	1.15 (0.76–1.74)	0.89 (0.58–1.34)	0.96 (0.65–1.44)
			1.01 (0.84–1.20)			0.98 (0.79–1.20)			1.12 (0.81–1.54)
			0.91 (0.72–1.15)			0.93 (0.70–1.22)			0.82 (0.51–1.32)
Visible mold or musty smell in home	1.01 (0.82–1.25)	1.00 (0.83–1.20)	1.13 (0.95–1.33)	1.09 (0.84–1.42)	1.06 (0.86–1.32)	1.17 (0.95–1.43)	0.73 (0.50–1.06)	0.80 (0.55–1.17)	1.00 (0.73–1.37)
			1.08 (0.92–1.26)			1.09 (0.89–1.32)			1.05 (0.79–1.38)
			0.97 (0.78–1.19)			0.99 (0.77–1.26)			0.95 (0.64–1.43)
Dust mites in child's bedroom	1.01 (0.80–1.27)	1.00 (0.83–1.21)	0.96 (0.82–1.19)	0.96 (0.72–1.29)	1.08 (0.86–1.37)	0.91 (0.73–1.14)	1.13 (0.76–1.69)	0.82 (0.60–1.11)	1.18 (0.81–1.73)
			0.97 (0.82–1.15)			0.87 (0.71–1.05)			1.26 (0.87–1.81)
			1.03 (0.83–1.28)			1.06 (0.82–1.37)			0.94 (0.63–1.39)

RRs were adjusted for age, gender, race/ethnicity, household income level, inhaled corticosteroid use, leukotriene antagonist use, and season of enrollment.

[a] QoL scores for (1) functional limitations, (2) daytime symptoms, and (3) nighttime symptoms.

of diminished QoL. Other studies have looked at relationships among multiple exposures and between exposures and asthma outcomes. One study found that sensitization to dogs and cats increased in children with ETS and poor ventilation in the home.[29] Another study suggests that allergens and viruses act together to exacerbate asthma.[30] It is likely that chronic exposure to allergens and irritants among sensitive individuals increases bronchial reactivity, thus putting children at greater risk of exacerbation after acute exposure to trigger factors. Nonetheless, given the documented uncertainties regarding the efficacy of indoor home environmental modification, additional investigation will be necessary to clarify the role of exposure avoidance as a component of asthma interventions, particularly those taking place in the ED context.

Our study has several limitations. First, all of our data were obtained from caregiver report. In contrast, the NCICAS had independent evaluators assess home environments and sample for specific allergen content of vacuum-cleaner reservoirs. They found caregiver reports to be fairly accurate for ETS and furry pets but somewhat less reliable for cockroach and mold exposure.[19] In addition, our health care utilization data depend entirely on caregiver reports. Second, we performed no allergy testing and therefore cannot describe the prevalence of allergen sensitivity in the cohort. However, recent studies have shown high levels of sensitivity to the exposures investigated here among high-morbidity asthmatics. For example, the NCICAS found that 93.9% of the children in that study had a positive skin test to ≥1 of the allergens tested, with the highest numbers of patients sensitive to cockroach (68.6%) and dust mite (61.8%) allergens.[31] Thus, it is likely that a large proportion of the children in our cohort are indeed sensitive to the exposures discussed. Third, our analyses do not address the role of viral illnesses, which may account for the majority of asthma exacerbations in children.[32,33] We did address the seasonal nature of asthma exacerbation by enrolling patients in all months of the year, including those months in which the viral load is lower. Finally, our cohort of patients represents a high-morbidity population of children who rely heavily on the ED for asthma care. Our results, therefore, are not generalizable to other populations who may have less-severe or better-controlled asthma and who may report different patterns of health care utilization.

CONCLUSIONS

We found high levels of exposure to ETS and potential allergens among a high-morbidity population of urban children with asthma. Although we were unable to directly evaluate the role of this chronic allergen and tobacco exposure on the patients' airways, we noted little in the way of more distal clinical effects of these exposures. Specifically, with the exception of diminished asthma QoL among children exposed to both cockroaches and ETS, we found no reported evidence of an association between multiple exposures and increased morbidity or health care utilization. These data suggest that although the high levels of these exposures may contribute to the poor outcomes in this cohort, other factors may play a more important role in overall asthma morbidity and determining patterns of health care utilization.

ACKNOWLEDGMENTS

Support for this study and publication of this article was provided by the Robert Wood Johnson Foundation. This study was supported by grant M01-RR020359 from the General Clinical Research Center Program of the National Center for Research Resources, National Institutes of Health, Department of Health and Human Services

Technical assistance was provided by the National Program Office (director, Gary Rachelefsky, MD, Allergy Research Foundation Inc; deputy director, Amy Stone, American Academy of Allergy, Asthma and Immunology; and research associate, Suzanne Kennedy, PhD, American Academy of Allergy, Asthma and Immunology). We acknowledge the statistical support of Robert J. McCarter, ScD, Cheng Shao, MPH, and Karen Schlumpf, MPH, and the database support of Bruce M. Sprague.

REFERENCES

1. Institute of Medicine, Committee on the Assessment of Asthma and Indoor Air. *Clearing the Air: Asthma and Indoor Air Exposures*. Washington, DC: National Academy Press; 2000
2. Weitzman M, Gortmaker S, Walker DK, Sobol A. Maternal smoking and childhood asthma. *Pediatrics*. 1990;85:505–501
3. Gilliland FD, Li Y, Peters JM. Effects of maternal smoking during pregnancy and environmental tobacco smoke on asthma and wheezing in children. *Am J Respir Crit Care Med*. 2001;163:429–436
4. Chilmonczyk BA, Salmun LM, Megathlin KN, at al. Association between exposure to environmental tobacco smoke and exacerbations of asthma in children. *N Engl J Med*. 1993;328:1665–1669
5. Eggleston PA, Buckley TJ, Breysse PN, Wills-Karp M, Kleeberger SR, Jaakkola JJK. The environment and asthma in U.S. inner cities. *Environ Health Perspect*. 1999;107(suppl 2):439–450
6. Rosenstreich DL, Eggleston P, Kattan M, 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*. 1997;336:1356–1363
7. Nelson HS. The importance of allergens in the development of asthma and the persistence of symptoms. *J Allergy Clin Immunol*. 2000;105(6 pt 2):S628–S632
8. Tunnicliffe WS, Fletcher TJ, Hammond K, et al. Sensitivity and exposure to indoor allergens in adults with differing asthma severity. *Eur Respir J*. 1999;13:654–659
9. National Heart, Lung, and Blood Institute; National Asthma Education and Prevention Program. *Expert Panel Report 2: Guidelines for the Diagnosis and Management of Asthma*. Bethesda, MD: National Institutes of Health; 1997. NIH publication No. 97-4051
10. Pediatric Asthma Committee. *Pediatric Asthma: Promoting Best*

Practice Guide for Management of Asthma in Children. Milwaukee, WI: American Academy of Allergy, Asthma and Immunology; 1999
11. Kattan M, Mitchell H, Eggleston P, et al. Characteristics of inner-city children with asthma: the National Cooperative Inner-City Asthma Study. *Pediatr Pulmonol.* 1997;24:253–262
12. Shields AE, Comstock C, Weiss KB. Variations in asthma care by race/ethnicity among children enrolled in a state Medicaid program. *Pediatrics.* 2004;113:496–504
13. Friday GA Jr, Khine H, Lin MS, Caliguri LA. Profile of children requiring emergency treatment for asthma. *Ann Allergy Asthma Immunol.* 1997;78:221–224
14. Rand CS, Butz AM, Kolodner K, Huss K, Eggleston P, Malveaux F. Emergency department visits by urban African American children with asthma. *J Allergy Clin Immunol.* 2001; 105:83–90
15. Bukstein DA, McGrath MM, Buchner DA, Landgraf J, Goss TF. Evaluation of a short form for measuring health-related quality of life among pediatric asthma patients. *J Allergy Clin Immunol.* 2000;105:245–251
16. Gorelick MH, Brousseau DC, Stevens MW. Validity and responsiveness of a brief, asthma-specific quality-of-life instrument in children with acute asthma. *Ann Allergy Asthma Immunol.* 2004;92:47–51
17. Pirkle JL, Flegal KM, Bernert JT, Brady DJ, Etzel RA, Maurer KR. Exposure of the US population to environmental tobacco smoke: the Third National Health and Nutrition Examination Survey, 1988 to 1991. *JAMA.* 1996;275:1233–1240
18. Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion. Prevalence data: District of Columbia—2003. Tobacco use. Available at: http://apps.nccd.cdc.gov/brfss/race.asp?cat=TU&yr=2003&qkey=4394&state=DC. Accessed March 17, 2005
19. Crain EF, Walter M, O'Connor GT, et al. Home and allergic characteristics of children with asthma in seven U.S. urban communities and design of an environmental intervention: the Inner-City Asthma Study. *Environ Health Perspect.* 2002;110: 939–945
20. Sarpong SB, Hamilton RG, Eggleston PA, Adkinson NF. Socioeconomic status and race as risk factors for cockroach allergen exposure and sensitization in children with asthma. *J Allergy Clin Immunol.* 1996;97:1393–1401
21. Kitch BT, Chew G, Burge HA, et al. Socioeconomic predictors of high allergen levels in homes in the greater Boston area. *Environ Health Perspect.* 2000;108:301–307
22. Carter MC, Perzanowski MS, Raymond A, Platts-Mills TA. Home intervention in the treatment of asthma among inner-city children. *J Allergy Clin Immunol.* 2001;108:732–737
23. Vojta PJ, Randels SP, Stout J, et al. Effects of physical interventions on house dust mite allergen levels in carpet, bed, and upholstery dust in low-income, urban homes. *Environ Health Perspect.* 2001;109:815–819
24. Gotzsche PC, Johansen HK, Burr ML, Hammarquist C. House dust mite control measures for asthma. *Cochrane Database Syst Rev.* 2001;(3):CD001187
25. Woodcock A, Forster L, Matthew E, et al. Control of exposure to mite allergen and allergen-impermeable bed covers for adults with asthma. *N Engl J Med.* 2003;349:225–236
26. Terreehorst I, Hak E, Oosting AJ, et al. Evaluation of impermeable covers for bedding in patients with allergic rhinitis. *N Engl J Med.* 2003;349:237–246
27. Gergen PJ, Mortimer KM, Eggleston PA, et al. Results of the National Cooperative Inner-City Study (NCICAS) environmental intervention to reduce cockroach allergen exposure in inner-city homes. *J Allergy Clin Immunol.* 1999;103:501–506
28. Morgan WJ, Crain EF, Gruchalla RS, et al. Results of a home-based environmental intervention in urban children with asthma. *N Engl J Med.* 2004;351:1068–1080
29. Lindfors A, van Hage-Hamsten M, Rietz H, Wickman M, Nordvall SL. Influence of interaction of environmental risk factors and sensitization in young asthmatic children. *J Allergy Clin Immunol.* 1999;104:755–762
30. Green RM, Custovic A, Sanderson G, Hunter J, Johnston SL, Woodcock A. Synergism between allergens and viruses and risk of hospital admission with asthma: case-control study. *BMJ.* 2002;324:763–767
31. Gruchalla RS, Pongracic J, Plaut M, et al. Inner City Asthma Study: relationships among sensitivity, allergen exposure, and asthma morbidity. *J Allergy Clin Immunol.* 2005;115:478–485
32. Johnston SL, Pattemore PK, Sanderson G, et al. Community study of role of viral infections in exacerbations of asthma in 9–11 year old children. *BMJ.* 1995;310:1225–1229
33. Gergen PJ, Mitchell H, Lynn H. Understanding the seasonal pattern of childhood asthma: results from the National Cooperative Inner-City Asthma Study (NCICAS). *J Pediatr.* 2002; 141:631–636

Indoor Environmental Exposures Among Children With Asthma Seen in an Urban Emergency Department

Stephen J. Teach, Ellen F. Crain, Deborah M. Quint, Michelle L. Hylan and Jill G. Joseph

Pediatrics 2006;117;S152
DOI: 10.1542/peds.2005-2000M

PEDIATRICS®
OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Indoor Environmental Exposures Among Children With Asthma Seen in an Urban Emergency Department

Stephen J. Teach, Ellen F. Crain, Deborah M. Quint, Michelle L. Hylan and Jill G. Joseph

Pediatrics 2006;117;S152
DOI: 10.1542/peds.2005-2000M