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Perceived Neighborhood Safety and Asthma Morbidity in the School Inner-City Asthma Study

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Summary

Aim: The aim of this study was to investigate whether neighborhood safety as perceived by primary caregivers is associated with asthma morbidity outcomes among inner-city school children with asthma. Methods: School children with asthma were recruited from 25 inner-city schools between 2009 and 2012 for the School Inner-City Asthma Study (N = 219). Primary caregivers completed a baseline questionnaire detailing their perception of neighborhood safety and their children's asthma symptoms, and the children performed baseline pulmonary function tests. In this cross-sectional analysis, asthma control was compared between children whose caregivers perceived their neighborhood to be unsafe versus safe. Results: After adjusting for potential confounders, those children whose primary caregivers perceived the neighborhood to be unsafe had twice the odds of having poorly controlled asthma (odds ratio [OR] adjusted = 2.2, 95% confidence interval [CI] = 1.2–3.9, $P = 0.009$), four times the odds of dyspnea and rescue medication use (OR adjusted = 4.7; 95% CI = 1.7–13.0, $P = 0.003$, OR adjusted = 4.0; 95% CI = 1.8–8.8, $P < 0.001$, respectively), three times as much limitation in activity (OR adjusted = 3.2;

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SUPPORTING INFORMATION

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95% CI = 1.4–7.7, *P* = 0.008), and more than twice the odds of night-time symptoms (OR adjusted = 2.2; 95% CI = 1.3–4.0, *P* = 0.007) compared to participants living in safe neighborhoods. There was no difference in pulmonary function test results between the two groups. Conclusions: Primary caregivers' perception of neighborhood safety is associated with childhood asthma morbidity among inner-city school children with asthma. Further study is needed to elucidate mechanisms behind this association, and future intervention studies to address social disadvantage may be important.

Keywords

asthma; pediatrics; inner-city; socioeconomic factors; stress; psychological; disparities

INTRODUCTION

Asthma is one of the most common chronic diseases affecting children in the United States,[1] particularly among those living in poor, urban environments.[2] It is therefore essential to understand factors that lead to disparities and worsened outcomes in this population. Among the many elements that affect asthma morbidity, exposure to psychosocial stress appears to be very important.[3,4] Social disadvantage plays a prominent role in accounting for health disparities across minority groups, and this may be mediated through psychosocial stress.[5] Perceived safety of the child's neighborhood is likely to be a useful marker for the child's exposure to stress and social disadvantage.

Children living in neighborhoods perceived to be unsafe by their caregivers have higher levels of reported lifetime asthma when compared with children living in neighborhoods perceived to be safe.[2,6] Furthermore, caretaker-reported exposure to community violence is associated with childhood asthma morbidity.[7] Exposures to violence and victimization have also been shown to affect asthma morbidity among adult patients.[8,9] However, while there are data regarding an association between caregiver perception of safety and asthma diagnosis as well as data regarding violence and asthma morbidity, to the best of our knowledge, there are no previous studies examining the association between caregivers' perception of neighborhood safety and asthma morbidity outcomes in children, particularly in the urban, poor, primarily non-white, school-based setting, such as the School Inner City Asthma Study (SICAS).

We aimed to investigate the relationship between perceived neighborhood safety and asthma morbidity among inner-city school children with asthma. We hypothesized that in this high-risk population, those whose primary caregivers perceived their neighborhood to be unsafe would have greater asthma morbidity when compared with those whose caregivers perceived their neighborhood to be safe, independent of psychosocial stress of the caregiver, socioeconomic status, and other factors.

MATERIALS AND METHODS

SICAS is an ongoing prospective, school-based study, the methods of which have been described previously.[10] The primary aim of SICAS is to comprehensively evaluate the role

of classroom, school, and home exposures, including allergens, mold, air pollution, endotoxin, caregiver stress, and neighborhood safety, on asthma morbidity in urban children with asthma. The study aims to recruit elementary school-aged students (ages 5–15 years) with asthma from multiple schools in a single, northeastern urban city, and collects detailed information, including assessment of asthma symptoms, home, and child-care characteristics, pulmonary function tests, and specific allergen sensitivity data.

The eligibility requirements for SICAS, similar to other inner-city asthma studies,[11] include physician-diagnosed asthma and either wheezing, use of preventative medicines for asthma, or unscheduled physician or nurse visits for asthma in the 12 months prior to screening. SICAS does not require a specific level of asthma severity for inclusion in the study. At the baseline visit, which takes place during the summer, trained interviewers obtain informed consent and then administer a comprehensive survey to the participant's caregiver that includes questions regarding demographics, past medical history, asthma morbidity, perceived stress levels, and perception of neighborhood safety. Spirometry is also performed by the participants at the baseline visit.

SICAS began enrolling participants in 2008. This analysis was performed for study participants enrolled between years 2009 and 2012, as the questions regarding neighborhood safety were added to the questionnaire in 2009. A total of 220 participants from 25 inner-city schools were enrolled over that time period. Baseline questionnaire data were missing for one participant, therefore the analysis was performed on 219 participants.

This study was approved by the Institutional Review Board of Boston Children's Hospital and Brigham and Women's Hospital. Written informed consent, and, where age appropriate, assent, were obtained for all participants.

Primary Predictor

The caregiver's perception of neighborhood safety was assessed at the baseline visit with a dichotomous "yes" or "no" response to the question "Is it safe to walk alone in the neighborhood at night?" This question was modeled from a similar question contained within the Community Survey Questionnaire of the Project on Human Development in Chicago Neighborhoods.[12]

Outcomes

Poor Asthma Control—Asthma control was also assessed at the baseline visit, based on caregiver responses to questions about the child's asthma symptoms in the past 4 weeks. Symptom categories of interest included dyspnea, nighttime symptoms, decreased daytime activity, and rescue medication use. For each symptom category, responses were categorized as "well controlled" or "not well controlled" asthma, based on the National Asthma Education and Prevention Program (NAEPP) guideline-recommended criteria for assessment of asthma control.[1] More specifically, poor control was defined as shortness of breath greater than twice weekly in the past 4 weeks, nighttime awakenings due to asthma at least once during the past 4 weeks, limitation in activity whereby the child's asthma kept him/her from getting things done some, most, or all of the time in the past 4 weeks, or use of

rescue asthma medication greater than or equal to twice weekly in the past 4 weeks. A composite score was created to reflect overall asthma control, again reflecting recommendations in the NAEPP guidelines,[1] whereby if the participant had poor control in any of the areas described above, he/she was considered to have poor overall control. We chose this composite outcome to reflect actual clinical practice, as decisions regarding changes in treatment regimens tend to be based on assessment of control.

Missed School due to Asthma—Caregivers were asked how many days of school their child missed due to asthma in the past 12 months. We considered >5 missed school days to represent substantial morbidity. This number was based on previously published data for missed school days among asthmatic children in public school.[13]

Health Care Utilization—Caregivers were asked whether their child had any hospitalizations for asthma in the last 12 months and whether there were any unscheduled physician visits for asthma in the last 12 months.

Pulmonary function—Spirometry (Koko spirometer, nSpire Health, Inc., Longmont, CO) was performed at the baseline visit in accordance with the American Thoracic Society (ATS) guidelines[14] and compared to predicted outcomes from the National Health and Nutrition Examination Survey III.[15] Spirometry results were reviewed for acceptability and reproducibility according to ATS guidelines.[14,16] Values of interest that were analyzed included the percent predicted forced expiratory volume in one second (FEV_1), percent predicted forced vital capacity (FVC), the ratio of FEV_1/FVC, and the percent predicted forced expiratory flow between 25% and 75% of FVC ($FEF_{25–75}$).

Statistical Analysis Strategy

The univariate analysis of the relationship between exposure and outcome measures employed 2 × 2 tables for categorical variables and independent sample *t*-test or Wilcoxon rank sum test for continuous variables, depending on the normal distribution of outcome. We estimated unadjusted and adjusted odds ratios for the effect of the exposure of interest on poor asthma control using logistic regression models. Covariates for multivariable models included known or suspected confounders to the relationship between neighborhood safety and the outcomes, as identified in the literature[3,6,17-20] or hypothesized by the study team. In particular, we considered markers of socioeconomic status (SES) including caregiver education (<high school graduation), caregiver employment status (<1 employed adult in the home), and poverty (annual household income <$25,000). Caregiver-perceived stress was also included, using the 4-item perceived stress scale [PSS-4], a validated measure of the degree to which situations in a person's life are perceived as stressful,[21] which is scored out of 16, with higher scores indicating higher degrees of stress. We also evaluated participant exposure to tobacco smoke (≥1 smoker in household), use of inhaled corticosteroids by the participant (use of inhaled corticosteroid over previous 12 months), as well as other standard measures such as participant age, participant gender, caregiver gender, and race of the participant (Black, White, Hispanic, Mixed, or Other) in our models. Covariate data were obtained via caregiver questionnaire at the baseline visit.

The only variable with substantial missingness was income, which had 181 respondents (approximately 17% missing). Missing income values were coded with a third category so as not to be excluded via case-wise deletion. Statistical computations were performed using SAS software, Version 9.2 of the SAS System for Unix.[22]

RESULTS

Characteristics of the Child

The participants (N = 219) had a mean age of 7.8 years (standard deviation [SD] 1.9) and were mainly Black or Hispanic (40.2% and 26.5% of the cohort, respectively), see Table 1. The frequency of inhaled corticosteroid use among participants in the study was 54.8%. The proportion of participants with poorly controlled asthma, as well as spirometry data and school absence data for the whole cohort, are displayed in Table 2.

Caregiver and Household Characteristics

The majority of caregivers were female (97.2%). Forty-five percent of caregivers felt that it was not safe to walk alone in the neighborhood at night. Forty-five percent of participants had a household income below $25,000. In 15.1% of households, no adult had completed a high school education or equivalent. In 25.4% of households there were no employed adults in the home. The mean caregiver score on the PSS-4 was 5.9 (SD 3.0). There was at least one smoker in the home in 37.9% of households.

Perception of Neighborhood Safety and Asthma Morbidity

The proportions of participants with poorly controlled asthma based on individual symptom categories including dyspnea, nighttime awakening, limitation in activity, frequent rescue medication use, and overall poor asthma control (based on the composite score described above) are displayed in Figure 1 and E-Table 3. The final model included adjustment for participant age, participant gender, participant race, household income, participant exposure to tobacco smoke, use of inhaled corticosteroids by the participant, and caregiver stress. The final model did not include gender of the caregiver, as caregivers were female in 97.2% of cases and when included in the model, outcomes did not change substantially. While household income was included in the final model, we did not include education or employment status. When education and employment were included as covariates the model estimates did not change appreciably, therefore they were removed from the final model.

Participants whose caregivers perceived their neighborhood to be unsafe at night independently had over four times the odds of dyspnea (odds ratio [OR] unadjusted = 4.6; 95% confidence interval [CI] = 1.8–11.3, $P = 0.001$, OR adjusted = 4.7; 95% CI = 1.7–13.0, $P = 0.003$), three times as much limitation in activity (OR unadjusted = 3.7; 95% CI 1.6–8.5, $P = 0.002$, OR adjusted = 3.2; 95% CI = 1.4–7.7, $P = 0.008$), and more than twice the odds of nighttime symptoms (OR unadjusted = 2.4; 95% CI 1.4–4.2, $P = 0.001$, OR adjusted = 2.2; 95% CI = 1.3–4.0, $P = 0.007$) compared to participants living in safe neighborhoods. Participants whose caregivers perceived the neighborhood to be unsafe had four times the odds of rescue medication use (OR unadjusted = 2.9; 95% CI 1.5–5.7, $P = 0.002$, OR adjusted = 4.0; 95% CI = 1.8–8.8, $P < 0.001$). Participants whose caregivers perceived their

neighborhood to be unsafe at night independently had over twice the odds of having poorly controlled asthma, compared with those whose caregivers perceived it to be safe (OR unadjusted 2.4; 95% CI 1.4–4.1, $P = 0.002$, OR adjusted = 2.2; 95% CI = 1.2–3.9, $P = 0.009$). The multivariable model for the association between perceived neighborhood safety and poor asthma control is shown in E-Table 4.

The adjusted odds of missing >5 school days over the last 12 months approached statistical significance (OR unadjusted 1.8; 95% CI 1.0–3.2, $P = 0.038$, OR adjusted = 1.8; 95% CI 0.9–3.3, $P = 0.072$) among those participants whose caregivers perceived their neighborhood to be unsafe, compared with those who perceived it to be safe.

There were no statistically significant differences in hospitalizations for asthma in the last 12 months or in unscheduled physician visits in the last 12 months between the participants whose caregivers perceived the neighborhood to be safe versus unsafe (OR unadjusted 1.4; 95% CI 0.5–4.1, $P = 0.514$, OR unadjusted 1.1; 95% CI 0.6–1.9, $P = 0.685$, respectively).

No associations of perceived neighborhood safety with the child's spirometric performance were detected (E-Table 5).

DISCUSSION

We show that among children whose caregivers perceive the neighborhood to be unsafe, there is a higher rate of uncontrolled asthma as compared to children whose caregivers perceive the neighborhood to be safe, independent of known potential confounders. We report that the individual symptoms that account for poor asthma control, including dyspnea, nighttime symptoms, limitation in activity, and need for rescue medication, are also each increased in the children living in neighborhoods perceived to be unsafe. There are multiple possible explanations for the associations we found, including that in unsafe neighborhoods, there is greater exposure to violence, greater psychosocial stress among caregivers, lower SES, and less access to healthcare services, which in turn may all affect asthma morbidity. Both groups have mean spirometry results in the normal range and no difference was observed between groups. This is not surprising, given previous research suggesting that spirometry measures may not be reflective of asthma severity in children.[23,24]

The association we found between reported neighborhood safety and asthma morbidity may be mediated by higher rates of exposure to violence in the "unsafe" communities. Previous studies have shown that exposures to violence and victimization are associated with asthma morbidity.[25] For example, an association exists between hospitalization rates for assault and hospitalization rates for asthma.[26] In the Inner City Asthma study, Wright et al.[7] showed that greater parental report of exposure to violence was associated with higher rates of reported symptom days in the child and more nights of caretaker lost sleep. In a separate study in high school students, those who reported being victimized in the past year had increased odds of having had an asthma episode in the past year.[27] In these same students, missing school in the past 30 days due to feeling unsafe was also associated with having had an asthma episode in the past year. Asthmatic children who witnessed violence or whose caregivers witnessed violence or felt unsafe were more likely to experience nighttime

symptoms.[28] Exposure to violence may also mediate the relationship between other environmental risk factors and asthma. For example, in an urban community-based pregnancy cohort, environmental nitrogen dioxide was associated with asthma diagnosis, exclusively among children who had above-median exposure to violence.[19]

While our questionnaire addressed safety of walking alone in the neighborhood at night, and did not specifically ask about exposure to violence, we speculate that caregivers' responses to this question are influenced by exposure to violence in the community. Vangeepuram et al found that when parents were asked about various aspects of neighborhood safety, both safety while walking in the neighborhood and safety from crime were associated with a diagnosis of asthma among their children. However, other aspects of neighborhood safety such as conditions of sidewalks and adequacy of street lighting were not.[2] Thus exposure to violence may play an important role in explaining the association between perceived neighborhood safety and asthma morbidity in our study.

Another possibility is that living in an "unsafe" neighborhood may be a cause of psychosocial stress. This underlying stress, in turn, may contribute to higher rates of asthma and worsened asthma symptoms, as has been shown in prior studies.[3,17,20,29,30] Proposed mechanisms behind the association between stress and asthma include heightened inflammatory responses in the setting of stress[31-33] as well as effects of stress on the hypothalamic-pituitary-adrenal axis and the sympathetic-adrenal-medullary axis.[34] We attempted to explore this further by controlling for the caregiver's stress level in our model, using the PSS-4. Interestingly, perception of neighborhood safety maintained an independent association with asthma morbidity, even when accounting for stress. In fact, when we removed stress from the model, there was no change in the association between perceived neighborhood safety and asthma morbidity. This contrasts with previous work that found that psychosocial stress was able to partially explain the relationship between caretaker-reported exposure to violence and childhood asthma morbidity.[7] It is unclear why stress was not a confounder in our analysis. We speculate that in our population, the caregiver's perception of neighborhood safety was mostly influenced by elements of security, danger, and exposure to violence, rather than underlying chronic stress. It is, however, possible that the personal nature of the PSS-4 questions is such that respondents may choose not to answer candidly and this may not have been a good measure of stress in our population.

A complex relationship exists between the safety of the neighborhood one lives in as well as other factors such as SES, psychosocial stress, access to healthcare services, and coping habits such as tobacco smoking, which in turn all affect asthma morbidity. We attempted to disentangle these factors in the current analysis by accounting for them in our model. We included household income as a marker of SES, use of inhaled corticosteroids as an indicator of access to healthcare as well as an indicator of asthma control, PSS-4 as a measure of underlying caregiver stress, and exposure to tobacco smoke. Importantly, the relationship between the perception of neighborhood safety and asthma control held up after including these factors in the multivariable model.

We acknowledge that our study comprises a primarily poor, inner-city, non-white population. Therefore we are limited in generalizability to neighborhoods in other settings. However, it is of interest that despite our participants primarily living in similar neighborhoods and attending nearby schools in a community, there was disparate perception of safety, which was independently associated with asthma morbidity, suggesting further sub disparities in a population already known to be at disproportionate risk for asthma morbidity. We recognize that the measure of neighborhood safety in our study is based on subjective responses to a questionnaire item regarding perceived safety of walking alone at night. Future studies should also employ more objective data, such as geographic information systems-derived crime rate data. It is possible that some of our findings are driven by the particular population in our study. Forty-five percent of caregivers in our study reported feeling unsafe in their neighborhood at night, as compared to a previous study in which only 25% of urban caregivers reported feeling unsafe in their neighborhood.[28] The reason for the higher proportion in our study is not clear but this may reflect differences in the cities or years in which these studies were conducted. Another potential limitation is that perceived neighborhood safety and the participants' symptoms were reported by the caregiver rather than the participant. However, our group has previously shown that in this cohort, there was good agreement between caregiver and participant responses on screening surveys.[35] Prior studies have also used caregiver responses to predict childhood outcomes[2,17,20,30] and there is extensive research linking parental stress and depression to childhood asthma morbidity.[36] Furthermore, this study was of an elementary school-aged population, with 97.3% of participants aged 11 years or younger, which is an age at which parents typically assist with providing the medical history. There were some missing data in our study, including 17% of respondents who did not provide information on income and 13% of participants who performed spirometry but whose results did not meet criteria for acceptability and reproducibility and were therefore not used in the analysis. There were no other variables with >3% missing data. We do not believe that missing data impacted the results of our study. Finally, while we attempted to control for known and suspected confounders as indicated above, it is possible that unmeasured confounders may affect the relationship between neighborhood safety and asthma morbidity.

We believe that our study has important clinical implications. During evaluation of poorly controlled asthma among children from the inner-city, clinician awareness of the social context in which the pediatric patient is living may be extremely relevant. Knowledge that the caregiver perceives the neighborhood to be unsafe may lead to further discussion that can ultimately uncover the reasons for increased asthma symptoms. These may include exposure to community violence that precludes access to neighborhood pharmacies or healthcare and/or leads to reduced physical activity, or increased exposure to cigarette smoke as a coping mechanism for stress. Further study is needed to elucidate the most effective measures to address these issues, but these may include the services of social workers in asthma clinic as well as physician advocacy to policy makers to reduce disparities between asthma-sufferers from different socioeconomic backgrounds. From a research standpoint, future studies should aim to better understand the pathophysiology that underlies links between exposure to neighborhood safety and asthma severity.

CONCLUSION

Our study found that primary caregiver perception of neighborhood safety was associated with childhood asthma control in a cohort of inner-city school children. Our findings are consistent with previous studies and add to a growing body of literature that suggests that social disadvantage, psychosocial stress, and unsafe neighborhoods are associated with asthma morbidity. Further study is needed to elucidate mechanisms underlying the association. Greater understanding may indicate the need for intervention studies designed to reduce psychosocial stress and social disadvantage.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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ABBREVIATIONS

ATS	American Thoracic Society
CI	confidence interval
$FEF_{25–75}$	forced expiratory flow between 25% and 75% of the forced vital capacity
FEV_1	forced expiratory volume in one second
FVC	forced vital capacity
IFN	interferon
IL	interleukin
NAEPP	National Asthma Education and Prevention Program
OR	odds ratio
PSS-4	4-item perceived stress scale
SD	standard deviation
SES	socio economic status
SICAS	School Inner City Asthma Study
TRP	traffic related air pollution

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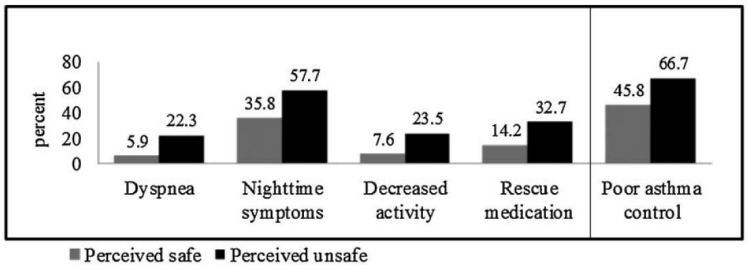

Fig. 1.

Asthma control over past 4 weeks in Inner-City Asthmatic Children (N = 219). Dyspnea: shortness of breath > twice weekly, Nighttime symptoms: nighttime awakenings due to asthma ≥ once; Decreased activity: limitation in activity > some of the time; Rescue medication: used rescue medication > twice weekly; Poor asthma control: composite score reflecting poor control in any of the areas described above. $P < 0.01$ for all comparisons shown.

TABLE 1

Baseline Characteristics of School Inner-City Asthma Study Participants (N = 219)

Characteristic	Count (%)
Age, mean (SD), years	7.8 (1.9)
Female gender	113 (51.6)
Female gender of caregiver (N = 218)	212 (97.2)
Race	
Black	88 (40.2)
Hispanic	58 (26.5)
White	14 (6.4)
Mixed	39 (17.8)
Other	20 (9.1))
Caregiver feels neighborhood is unsafe at night	99 (45.2)
Household income <$25,000 (N = 181)	82 (45.3)
Caregiver graduated from high school	186 (84.9)
At least one employed adult in the home (N = 213)	159 (74.6)
Family history of asthma[1]	173 (79.0)
At least one smoker in the home	83 (37.9)
Caregiver's PSS[2] score, mean (SD)	5.9 (3.0)
Use of inhaled corticosteroid	120 (54.8)

Data presented as count unless otherwise indicated. SD, standard deviation.

[1] Family history includes immediate family plus grandparents.

[2] Four-item perceived stress scale, score out of 16, where higher score indicates more stress.

TABLE 2

Outcomes for School Inner-City Asthma Study Participants (N =219)

Characteristic	Count (%)
Dyspnea[1] (N = 212)	28 (13.2)
Frequent nighttime awakening due to asthma[2] (N = 217)	99 (45.6)
Interference with normal activity[3] (N = 217)	32 (14.7)
Frequent rescue medication use[4] (N = 218)	49 (22.5)
Poor asthma control[5]	121 (55.3)
Spirometry: (N=190)	
EV_1 percent predicted, mean (SD)	101.0 (19.1)
FEV_1/FVC ratio × 100, mean (SD)	86.9 (7.8)
School absence due to asthma, more than 5 days in previous 12 months (N = 218)	75 (34.4)
School absence due to asthma in last 12 months (N = 218), median (IQR), days	4 (0,9)

FEV_1, forced expiratory volume in one second; FEV_1/FVC, FEV_1 divided by forced vital capacity; IQR, interquartile range; SD, standard deviation.

[1] Shortness of breath > twice weekly over the previous 4 weeks.

[2] ≥ 1 nighttime awakening due to asthma in the previous 4 weeks.

[3] Child's asthma kept them from getting things done some, most, or all of the time in previous 4 weeks.

[4] Use of rescue asthma medication > twice weekly over previous 4 weeks.

[5] Composite score: child's asthma is poorly controlled, based on having poor control in any of the above areas (dyspnea, frequent nighttime awakening due to asthma, frequent rescue medication use, or interference with normal activity).