



Letters

Associations among neighborhood greenspace, neighborhood violence, and children's asthma control in an urban city

Among 6.1 million children with asthma,¹ 38% have uncontrolled asthma, leading to increased pediatric emergency department (ED) visits, hospitalizations, and health care costs.² Uncontrolled asthma unequally harms children from lower-income, racial/ethnic minority families.¹ Disparities in asthma control have been attributed to differential exposures to poverty, living in unsafe, stressful neighborhoods, and unhealthy physical environments.³ One modifiable factor that may improve asthma control is the availability of neighborhood greenspace (ie, land with grass, trees, or other vegetation). Greenspace is associated with increased physical activity and decreased stress, environmental heat, and air pollution and disproportionately benefits white, affluent neighborhoods.⁴ Although these variables are associated with improved pediatric asthma control, testing associations between greenspace and asthma control has produced mixed results,⁵ potentially because of failure to account for neighborhood-level factors that influence children's exposure to greenspace, such as neighborhood violence. Living in an unsafe neighborhood is associated with increased stress and spending less time outside, resulting in increased exposure to indoor allergens and secondhand smoke (SHS). Children living in areas with higher violent crime have poorer asthma control than those in areas with lower crime rates.⁶ Our study examined whether the availability of neighborhood greenspace was associated with improved asthma control and whether neighborhood violence might modify that association by limiting children's exposure to greenspace.

This cross-sectional study used data from a larger study of predominantly African American, Medicaid-insured children with persistent asthma recruited from an urban pediatric ED after an asthma exacerbation.⁷ It was approved by the Johns Hopkins Hospital Institutional Review Board. At baseline we collected data on demographic and social risk, SHS exposure, asthma medication use, and child blood and saliva samples to determine allergen sensitization to indoor and outdoor allergens and SHS exposure. Medication use was based on the asthma medication ratio (AMR). The child's home address was geocoded to neighborhood-level variables of greenspace and violence.⁸

Greenspace was measured using the normalized difference vegetation index (NDVI), an index from –1 to 1 where higher numbers indicate greener vegetation areas, calculated using satellite data. Violence was measured using the violent crime victimization rate calculated from police-reported crime data. Level of asthma control, categorized as not well controlled or very poorly

controlled (the worse outcome), was based on parents' report of their child's asthma symptom days, symptom nights, activity limitation, and rescue inhaler use. For missing data on AMR and social risk (11% and 8%, respectively), we used the Markov Chain Monte Carlo method of multiple imputation with 10 data sets. Hypotheses were tested using logistic regression and Stata software, version 15.1 (StataCorp, College Station, Texas).

The sample of 196 children was predominantly male (65%), African American (95%), and Medicaid insured (95%). Most children had very poorly controlled asthma (55%), SHS exposure (59%), and sensitization to indoor and outdoor allergens (83% and 63%, respectively). Most caregivers were single (78%) and the child's biological mother (93%). The NDVI values ranged from 0.00 to 0.17 (mean [SD] 0.07 [0.04]). Violent crime victimization rate ranged from 4.94 to 52.23 violent crime victimizations per 1000 US Census tract residents (mean [SD], 20.75 [9.74]).

Multivariable logistic regression results indicate that greenspace was not associated with asthma control (model 1 in Table 1). However, AMR was associated with asthma control (adjusted odds ratio, 2.41; 95% CI, 1.18–4.94). Furthermore, violence was not associated with the level of asthma control, but AMR remained associated with asthma control (adjusted odds ratio, 2.41; 95% CI, 1.18–4.96) (model 2 in Table 1). An interaction term between violence and greenspace was added into a logistic regression model to test moderation. As shown (model 3 in Table 1), violence did not moderate the association between greenspace and the level of asthma control. In sensitivity analyses controlling for reported length of time in the neighborhood, caregiver age, and number of allergen sensitizations, results were unchanged.

Our data indicate that the availability of greenspace was not related to children's asthma control, and neighborhood violence did not moderate this association. These null results align with a prior Australian study failing to find associations between the interaction of greenspace and area safety on children's asthma diagnosis, despite using different populations and measures for greenspace and violence.⁹

There are several study limitations. Although NDVI is an objective and validated measure of neighborhood greenspace and measures quantity of green vegetation, NDVI does not specifically measure characteristics of greenspace associated with improved child health. For example, NDVI does not distinguish between a vacant lot of weeds and a neighborhood park that may encourage physical activity and psychological restoration, pathways through which greenspace improves health. We lacked data on children's actual exposure to greenspace, which might have occurred in a different geographic area, such as a friend's home or at school. Asking about the location and duration of outdoor time may provide a more comprehensive estimate of greenspace exposure.

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Table 1
Logistic Regression Examining the Odds of Very Poorly Controlled Asthma in 167 Patients

Variable	Unadjusted relationships odds ratio (95% CI)	Adjusted relationships odds ratio (95% CI)		
		Model 1	Model 2	Model 3
Child age	1.06 (0.95–1.18)	NA	NA	NA
Child sex (male)	1.25 (0.21–7.68)	NA	NA	NA
Social risk index ^a	1.13 (0.93–1.37)	1.18 (0.93–1.50)	1.18 (0.92–1.51)	1.84 (0.93–1.51)
Season at baseline				
Fall	1 [Referent]	1 [Referent]	1 [Referent]	1 [Referent]
Winter	1.69 (0.81–3.51)	1.25 (0.54–2.92)	1.26 (0.54–2.93)	1.26 (0.54–2.94)
Spring	0.92 (0.42–2.02)	0.96 (0.40–2.27)	0.95 (0.40–2.25)	0.97 (0.41–2.29)
Summer	1.23 (0.54–2.80)	0.81 (0.31–2.12)	0.81 (0.31–2.13)	0.81 (0.31–2.14)
Asthma medication ratio ≥ 0.50	2.20 (1.20–4.05) ^b	2.41 (1.18–4.94) ^b	2.41 (1.18–4.96) ^b	2.45 (1.18–5.10) ^b
Indoor allergen sensitization ^c	0.60 (0.27–1.36)	NA	NA	NA
Outdoor allergen sensitization ^d	0.64 (0.35–1.18)	0.56 (0.29–1.11)	0.56 (0.28–1.11)	0.56 (0.28–1.10)
Secondhand smoke exposure ^e	0.72 (0.39–1.31)	0.55 (0.27–1.10)	0.55 (0.27–1.11)	0.54 (0.27–1.09)
Greenspace	1.04 (0.59–1.83)	1.01 (0.93–1.10)	NA	0.98 (0.79–1.21)
Violence ^f	1.01 (0.98–1.04)	NA	1.00 (0.97–1.03)	0.99 (0.91–1.07)
Interactions				
Violence $\times$ greenspace	NA	NA	NA	1.00 (0.99–1.01)

Abbreviation: NA, not applicable.

^aSocial risk index includes high school graduate/general educational development or less, single-parent household, Medicaid insured, unemployed, 4 or more children living in the home, parent Centers for Epidemiological Studies Depression score of 16 or higher, having lived 1 year or more in the current home, and perceived their neighborhood as having a weak sense of community (scores range from 0 to 8, with higher scores indicating greater risk).^b $P < .05$.^cIndoor allergen sensitization was positive if the IgE antibody level was 0.35 kU/L or higher for 1 or more indoor allergen (mouse, cockroach, cat, dog, *Aspergillus* mold, or house dust mite).^dOutdoor allergen sensitization was positive if the IgE antibody level was 0.35 kU/L or higher for 1 or more outdoor allergen (timothy grass, *Alternaria* mold, oak tree, or common ragweed).^eSecondhand smoke exposure was positive if salivary cotinine level of 1.00 ng/mL or higher.^fViolence measured as violent crime victimization rate per 1000 US Census tract residents.

Using existing data constrained the sample size, sample variability, and number of variables for examination. Although a power analysis demonstrated that the sample size was sufficient to test our primary hypothesis, it was insufficient to test moderation. In addition, all participants had uncontrolled asthma, further limiting our power to detect differences between children with not well-controlled and very poorly controlled asthma. We purposefully recruited children with uncontrolled asthma because they experience the highest asthma burden. However, this diminished variability may have biased results toward the null.

Despite these study limitations, multiple methods and informants (geocoding, crime statistics, and physiologic measures) were used to understand how neighborhood factors are linked to asthma control in high-risk children. The study harnessed satellite data to calculate NDVI and included neighborhood violence as a contextual factor to determine potential benefits of neighborhood greenspace for children with asthma.

Results highlight the complexities of studying the associations between neighborhood factors and asthma control in high-risk children. Researchers previously found that elements of neighborhood context (eg, housing-code violations) were associated with increased allergen exposures, potentially increasing asthma morbidity.¹⁰ Similar to housing-code violations, greenspaces are not randomly located but rather colocated with other environmental and social factors. Further research in this area should collect primary, longitudinal data using a larger sample of children with more variability in asthma control levels. Effective ways to modify neighborhood environments that are toxic to children's health, particularly for children with asthma, need to be explored.

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References

- Zahrn H, Bailey C, Damon S, Garbe P, Breyse P. *Vital signs. In: Asthma in Children—United States, 2001–2016*. Atlanta, GA: US Dept of Health and Human Services/Centers for Disease Control and Prevention; 2018:149–155.
- Nurmagambetov T, Kuwahara R, Garbe P. The economic burden of asthma in the United States, 2008–2013. *Ann Am Thoracic Soc*. 2018;15(3):348–356.
- DePriest K, Butz A. Neighborhood-level factors related to asthma in children living in urban areas: an integrative literature review. *J School Nurs*. 2017;33(1):8–17.
- Markevych I, Schoierer J, Hartig T, et al. Exploring pathways linking greenspace to health. *Environ Res*. 2017;158:301–317.
- Dadvand P, Nieuwenhuijsen M. *Green space and health. Integrating Human Health into Urban and Transport Planning*. New York, NY: Springer; 2019:409–423.
- DePriest K, Butz A, Thorpe Jr RJ. The relationship between neighborhood safety and children's asthma: an integrative review. *J Pediatr Health Care*. 2018;32(6):600–611.
- Butz AM, Bollinger M, Ogborn J, et al. Children with poorly controlled asthma: Randomized controlled trial of a home-based environmental control intervention. *Pediatr Pulmonol*. 2019;54(3):245–256.
- DePriest K, Butz A, Gross D. Investigating the relationships among neighborhood factors and asthma control in African American children: a study protocol. *Res Nurs Health*. 2018;41(5):428–439.
- Feng X, Astell-Burt T. Is neighborhood green space protective against associations between child asthma, neighborhood traffic volume and perceived lack of area safety? multilevel analysis of 4447 Australian children. *Int J Environ Res Public Health*. 2017;14(5):543.
- Rosenfeld L, Rudd R, Chew G, Emmons K, Acevedo-García D. Are neighborhood-level characteristics associated with indoor allergens in the household? *J Asthma*. 2010;47(1):66–75.