Title: Associations of urban greenness with asthma and respiratory symptoms in Mexican American children

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KE conceptualized the study, supervised all aspects of the study, and led the writing of the manuscript. CK contributed to the collection of neighborhood-level data, performed data analysis, and contributed to the interpretation of results and the writing of the manuscript. NR provided feedback on the data analysis and contributed to the writing of the manuscript. SZ, PF and SN contributed to the writing of and provided feedback on the manuscript. VP contributed to the conceptualization of the study, provided feedback on the analysis, contributed to the interpretation of results and the discussion, and reviewed the manuscript.

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Abbreviations:
CASS: Chicago Asthma School Study
CI: confidence interval
IQR: interquartile range
MA: Mexican American
NDVI: Normalized Difference Vegetation Index
OR: odds ratio
SACMD: Study of Asthma in Children of Mexican Descent
SES: socioeconomic status
US: United States

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INTRODUCTION

Asthma is one of the most common childhood chronic conditions with approximately 19 million adults and seven million children affected in the United States alone. [1] The etiology of asthma and other allergic conditions is not fully understood, but environmental and lifestyle factors have been implicated in the inception of these conditions. In the United States, the prevalence of asthma and asthma related symptoms is disproportionately high in urban poor neighborhoods.[2-4] Although this might be due partly to sociodemographic factors, studies have suggested that urbanization and its detrimental impact on the natural environment and lifestyle might increase the risk of respiratory conditions.[3-6] In fact, children raised or born on a farm or in rural areas have a reduced risk of respiratory conditions.[7-10] Recently, there has been an increased emphasis on the effect of residential surrounding greenness on the risk of respiratory conditions. However, studies linking urban greenness and vegetation with respiratory health are limited and have yielded inconsistent findings.[11] While some studies linked greenness with increased risk of asthma and adverse respiratory conditions,[12-15] other investigations failed to demonstrate a clear association between greenness and childhood respiratory health.[16,17] A few studies, however, have demonstrated protective effects of urban greenness on the risk of allergies and respiratory conditions.[18-20] It has been speculated that increased urban greenness may protect against respiratory conditions through its positive impact on environmental biodiversity[21,22] and subsequently the human microbiome.[22,23] Recent research has shown variations in outdoor urban microbiome due to differences in surrounding vegetation[23] and there is an increasing body of literature linking the microbiome with allergic conditions.[24] Increased access to urban residential greenness has also been linked with increased physical activity, lower rates of overweight/obesity, reduced psychological stress, and better air quality;[20,25] factors that have been linked with respiratory health.[26-31] The limited evidence for favorable effects of urban greenness on respiratory health suggests that the protective effect of greenness may be modified by individual and neighborhood characteristics, such as individual and neighborhood low socioeconomic status (SES).[19,20]

In this study, we examined the associations of residential surrounding greenness with respiratory conditions among an urban sample of Mexican American children and tested whether these associations were explained or modified by individual- and neighborhood-level factors known to contribute to the development of asthma.

METHODS

Study design and data collection

Individual-level data used in this study were collected as part of the Study of Asthma in Children of Mexican Descent (SACMD), a population-based, cross-sectional study. The study was conducted between August 2004 and April 2005 among participants who were enrolled in the larger Chicago Asthma School Study (CASS)[32,33] between January and May of 2004. CASS targeted parents of all students in 15 public schools in Chicago asking them to complete a brief asthma screener. Parents of 9,895 students enrolled in these 15 schools responded completing the study questionnaire; a response rate of 74%. Of those, 6,896 students were of Mexican descent. For SACMD, parents of 2,851 students—all Mexico-born students (1,366) and a random sample of US-born students of Mexican descent (1,485)—were invited to participate in SACMD. Parents of 2,023 children (response rate=71%) completed a mailed questionnaire (*n*=199) or a telephone interview (*n*=1,824) regarding the respiratory health of their child, and provided information regarding demographic characteristics, immigration status, lifestyle and environmental characteristics, and early childhood infections. All study materials were available in both English and Spanish (91% of parents completed the study questionnaire/interview in Spanish). Of the 2,023 children whose parents participated in the SACMD, 1,915 provided complete information for all respiratory outcomes and covariates examined in this analysis. Both the CASS and the SACMD were approved by the Institutional Review Board of the University of Illinois at Chicago.

Outcome variables

Lifetime asthma refers to lifetime doctor-diagnosed asthma while questions on respiratory symptoms were similar to those used by the International Study of Asthma and

Allergy in Children (ISAAC) questionnaire. Lifetime wheezing refers to ever wheezing or whistling in the chest at any time in the past, and current wheezing refers to wheezing or whistling in the chest in the last 12 months. Current dry cough at night due to asthma or wheezing was determined via the question "In the last 12 months, has your child had a dry cough at night apart from a cough associated with a cold or chest infection?" Lifetime asthma, lifetime wheezing, and current wheezing are not mutually exclusive.

Greenness exposure

We first geocoded the address of each participant using GIS software (ArcGIS Desktop, Environmental Systems Research Institute, Redlands, CA). We then derived the Normalized Difference Vegetation Index (NDVI) from satellite images collected by the multispectral Landsat 5 Thematic Mapper mission;[34] We used the publicly available satellite imagery at a 30-m by 30-m resolution. The NDVI is an indicator of greenness based on land surface reflectance of specific visible (red) and non-visible (infrared) bands of spectrum. Healthy green vegetation reflects more radiation and absorbs more energy in the red wavelength than unhealthy vegetation or less-green as well as non-vegetated areas.[35] Values of the NDVI range from -1 (water) to +1 (dense green vegetation).[35] Landsat 5 data were acquired for clear-sky (cloud-free) days over the course of calendar year 2004, which covered much of the data collection period of the SACMD. Because the NDVI peaked in June of the year 2004, we examined NDVI data collected for the single date 23 June 2004. This was done in order to maximize greenness exposure variability among all participants[16] and represents a theoretical maximum greenness value for the year 2004. We created 100 m buffer distance around the residential address of each participant and abstracted mean NDVI values for that the 100 m buffer. This buffer distance has been used in similar analyses[16,20,36] and represents greenness that is immediately accessible to children.[37] In addition, we also abstracted mean NDVI values within 250 m[15,37] and 500 m[15,37] buffers of each child's residence in order to further explore the consistency of the effect of greenness exposure over greater distances and robustness of findings to buffer size.

Statistical analyses

Median level of NDVI was compared by category of respiratory outcomes and individual-level covariates using non-parametric tests (Wilcoxon Rank-sum test and Kruskal-Wallis test, where appropriate). We calculated Spearman's rank correlation coefficient for NDVI and all neighborhood-level covariates. We performed multilevel mixed-effect logistic regression analyses to estimate the association of NDVI (as a continuous variables) with respiratory health outcomes. We rescaled each participant's NDVI value for a given buffer distance by the IQR (the distance between the 25th and 75th percentiles)[37,38] and therefore the effect of greenness is interpreted for a one-IQR increase in greenness or going from the 25th percentile to the 75th percentile of NDVI. Children's neighborhood, the census tract in which they resided at the time of the survey, was specified as a random intercept in order to account for geographic clustering and potential confounding due to unmeasured neighborhood-level characteristics.

Covariates were included in the final models if they were associated with the outcome variables ($p \leq 0.05$) in bivariate associations, changed the estimate of the greenness-outcome association by $\geq$10%,[39,40] or were considered important covariates based on the literature. Multivariable logistic regression models were adjusted for age, gender, country of birth, place where child was born (urban/town versus village, rural, or farm), family history of asthma or allergies, number of siblings, daycare or pre-school attendance, access to a regular doctor or clinic, history of ear infection during infancy, viral infections during the first year of life, antibiotic use during the first year of life, ever breastfeeding, current exposure to cats and/or dogs, perinatal ETS exposure (i.e., a smoker was present in the home at the time of the child's birth), current ETS exposure (i.e., current smoker present in the home), and proximity to primary traffic arterials (data obtained from Illinois Department of Transportation for the year 2004.[41] In further analyses, we adjusted for population density (the number of people living in the census tract divided by the area of the census tract in square miles), neighborhood deprivation (a composite index of six indicators of SES for a given census tract),[42] neighborhood Mexican concentration (the percentage of people in the census tract who identify as Mexican), and the total number of crimes reported in the census tract for the year 2004 (aggregated from the Chicago Police Department data portal). We examined interactive effects of individual-level (i.e. gender, country of birth, place child was born, family history of asthma or allergies, perinatal ETS exposure, current ETS exposure, and proximity to traffic) as well as neighborhood-level (i.e., neighborhood deprivation, Mexican concentration, and total crime) covariates with NDVI by adding the product terms to the adjusted models.

All analyses described above were conducted using SAS version 9.4 (SAS Institute, Cary, NC). All statistical tests were two-sided, and a $p \leq 0.05$ was used to indicate statistical significance.

RESULTS

The prevalence of lifetime asthma, lifetime wheezing, current wheezing, and current dry cough at night was 6.7%, 17.0%, 6.1%, and 7.1%, respectively (Table 1). The mean age of participants was 9.96 years (SD 2.78) and of participants, 48.5% were male; 44.4% were born in Mexico; 15.3% had a smoker at home when the child was born; and 11.2% had a smoker at home at the time of the study. The median NDVI was 0.15 (IQR: 0.08), 0.15 (IQR: 0.08), and 0.14 (IQR: 0.06) for 100 m, 250 m, and 500 m buffers, respectively.

Median values of NDVI within 100 m of children's residences were significantly greater for children born in Mexico; children born or lived on a farm, village, or in a rural area during the first year of life; children currently exposed to cats and/or dogs, and those who lived within 250 m of a primary traffic arterial (Table 2). NDVI values were inversely and significantly correlated with neighborhood population density, neighborhood deprivation, neighborhood Mexican concentration, and the number of crime incidents (data not shown).

Higher NDVI within 100 m of children's residences was significantly associated with reduced odds of lifetime wheezing in unadjusted (odds ratio [OR]=0.82; 95% CI: 0.71, 0.95) and fully adjusted (aOR=0.82; 95% CI: 0.69, 0.96) models (Table 3). Increased greenness within 100 m of children's residences exerted protective effects, albeit statistically non-significant, on the odds of lifetime asthma, current wheezing, and current dry cough at night (Table 3).

In additional analyses, we discovered that current exposure to ETS modified the association of NDVI with lifetime asthma and that the protective effect of increased NDVI was observed only among children exposed to ETS (had a smoker at home) at the time of the survey. Among children with current exposure to ETS, the adjusted odds ratios for the association of a one-IQR increase in NDVI within 100 m, 250 m, and 500 m of children's residences with lifetime asthma were 0.43 (95% CI: 0.22, 0.87), 0.39 (95% CI: 0.18, 0.84), and 0.48 (95% CI: 0.26, 0.90), respectively (Table 4). However, we found no association of NDVI with lifetime asthma among children who were not exposed to a smoker in the home at the time of the study.

We also found statistically significant interaction between perinatal exposure to ETS with current dry cough at night as the outcome variable. The odds of current dry cough at night were reduced among children exposed to higher levels of NDVI within 100 m (aOR=0.53; 95% CI: 0.31, 0.92), 250 m (aOR=0.55; 95% CI: 0.31, 0.98), and 500 m (aOR=0.55; 95% CI: 0.35, 0.87) of their residences, but these inverse associations were observed only among children for whom a smoker was present in the home at birth (Table 5). Current and perinatal exposure to ETS did not significantly modify the observed inverse association of higher NDVI within 100 m of the children’s residences with the odds of lifetime wheezing. We did not observe interactions by other individual- or neighborhood-level covariates.

DISCUSSION

In a large sample of inner city MA children, we documented inverse associations of increased urban greenness with asthma and respiratory symptoms. It is worth noting that the level of greenness in Chicago based on our calculation of NDVI was generally low with little variation as demonstrated by the small IQRs for the different buffers we used. This might explain the small effect for greenness we found in the current study. Nonetheless, our study adds to the growing body of literature in support of protective effects of residential greenness on childhood respiratory and atopic conditions in the United States,[18] Canada,[20] and Europe.[19,43] The findings of our study are congruent with postulations of the biodiversity hypothesis[44] suggesting that less exposure to natural environments and biodiversity loss may lead to decreased microbial diversity in urban environments;[23] adversely influence the human microbiota; [22]and subsequently increase the risk of immune dysfunction, inflammation, and allergic conditions.[20,22,44,45] Recent research has shown variations in outdoor urban microbiome due to differences in surrounding vegetation.[23] and associations of urban greenness with increased environmental biodiversity.[21] Reduced environmental biodiversity has been linked with increased risk of atopy [22] with increasing evidence implicating adverse perturbations in the human microbiome in the etiology of allergic conditions.[24] Nonetheless, research linking residential surrounding greenness with asthma and allergic conditions is still limited and has yielded inconsistent findings that might be due to differences in study designs, greenness measures, timing of exposure assessment, and types of vegetation studied.[11]

Other mechanisms may also explain the protective effect of greenness on respiratory outcomes. Green vegetation improves local air quality [46-49] and may, in turn, reduces exposure to harmful air pollutants.[19] Access to green space has also been linked with reduced levels of stress[25,45,50,51] which is also associated with asthma and respiratory outcomes.[29,30] Moreover, increased exposure to greenness is associated with increased levels of physical activity [25,52,53] and decreased prevalence of overweight in children.[16] Obesity has been linked with and increased risk of asthma-related morbidity.[27,28]

In this study, the inverse associations of increased greenness with lifetime asthma and current dry cough at night were observed only in children exposed to ETS. These findings are in line with previous investigations showing that the protective effect of greenness on respiratory outcomes was more profound in participants with low SES [19,20] who are more likely to be exposed to ETS[54] and are particularly vulnerable to the risk of asthma.[55] For example, Sbihi et al.[20] found that the protective effect of urban greenness on incident asthma was only noted in those from communities with low levels of maternal education.[20] Maas et al.[19] also found that the inverse association of increased green space with the risk of chronic obstructive pulmonary disease was stronger among the less educated group. Although with different health outcomes, another study found that the protective effect of greenness on mortality and longer life expectancy was limited to areas with lower SES.[56]

It is also possible that smoking in urban areas might be associated with an increased likelihood of adults venturing outdoors to smoke[57,58] possibly in the company of their children who may benefit from the increased exposure to green space by being exposed to more microbes and physically active. These results might suggest that vulnerable populations living in urban areas might particularly benefit from residential surrounding green space but further research is still needed in this area.

The study has several limitations. As it is cross-sectional, temporality between exposure to residential surrounding greenness and respiratory outcomes cannot be established. We were unable to test several potential mechanisms (e.g., biodiversity hypothesis, increased air quality) that could explain the effect of residential surrounding greenness on respiratory conditions that we observed. Furthermore, we relied on the NDVI which is not a perfect measure of urban residential greenness and does not differentiate between different types of vegetation.[11] Our measure of greenness was based on the child's place of residence at the time of the study, was based on a single date, and does not reflect cumulative exposure to greenness nor exposure at birth or during infancy. Furthermore, we did not have data on the duration of residence at the current address nor on the address at birth. In addition, we were not able to account for the amount of time children spent in green areas around or far from their house.

Although studies have suggested that living on a farm or in a rural area might be protective against asthma and allergic conditions, our study adds to evidence pointing to possible protective effects of urban greenness that might reduce the detrimental impact of urbanization, especially on underserved and disadvantaged populations. Further research is needed in order to fully understand the effect of residential greenness on respiratory health outcomes, but if confirmed by future investigations our results have public health and policy implications for planning of land use and development of urban centers that provide opportunities for children to interact with natural environments.[43] We recommend that prospective studies attempt to characterize exposure to urban greenness over the course of infancy and childhood and incorporate data for investigating the possible mechanisms underlying the associations observed in this study.

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Table 1: Distribution of respiratory outcomes, median and interquartile range of residential surrounding greenness, and description of covariates among all children (*n*=1,915). **Variable**	n (%)
Lifetime asthma	
Yes	128 (6.7)
No	1787 (93.3)
Lifetime wheezing	
Yes	326 (17.0)
No	1589 (83.0)
Current wheezing	
Yes	116 (6.1)
No	1799 (93.9)
Current dry cough at night	
Yes	136 (7.1)
No	1779 (92.9)
Age (years)	
4-7	441 (23.0)
8-11	850 (44.4)
12-18	624 (32.6)
Gender	
Male	928 (48.5)
Female	987 (51.5)
Country of birth	
United States (not including Puerto Rico)	1045 (54.6)
Mexico	870 (45.4)
Place child was born or lived during 1st year of life	
Farm/rural/village	399 (20.8)
City or town	1516 (79.2)
Family history of asthma or allergies	
Yes	296 (15.5)
No	1619 (84.5)
Number of siblings	
≥3	1371 (71.6)
1-2	456 (23.8)
None	88 (4.6)
Child ever breast-fed	
Yes	1324 (69.1)
No	591 (30.9)
Current exposure to cats and/or dogs	
Yes	278 (14.5)
No	1637 (85.5)
Smoker present in the home at the time of child's birth	
Yes	293 (15.3)
No	1622 (84.7)
Current smoker present in the home	
Yes	215 (11.2)
No	1700 (88.8)
Proximity to traffic	
≤250 m	278 (14.5)
>250 m	1637 (85.5)
Greenness (NDVI)	**median (IQR)**
NDVI within 100 m of child’s residence	0.15 (0.08)
NDVI within 250 m of child’s residence	0.15 (0.08)
NDVI within 500 m of child’s residence	0.14 (0.06)

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Table 2: Median and interquartile range of NDVI across buffers, by strata of respiratory outcome and individual-level covariates among all children (*n*=1,915).

Variable	100 m median (IQR)	250 m median (IQR)	500 m median (IQR)
Outcomes			
Lifetime asthma			
Yes	0.141 (0.08)	0.140 (0.07)	0.137 (0.05)
No	0.150 (0.08)	0.150 (0.08)	0.140 (0.06)
Lifetime wheezing			
Yes	0.140 (0.09)*	0.140 (0.08)	0.136 (0.07)
No	0.151 (0.08)	0.151 (0.08)	0.142 (0.06)
Current wheezing			
Yes	0.139 (0.10)	0.139 (0.08)	0.137 (0.06)
No	0.150 (0.08)	0.150 (0.08)	0.140 (0.06)
Current dry cough at night			
Yes	0.145 (0.10)	0.144 (0.08)	0.139 (0.05)
No	0.150 (0.08)	0.150 (0.08)	0.140 (0.06)
Individual-level covariates			
Age (years)			
$\leq$7	0.149 (0.08)	0.150 (0.08)	0.138 (0.06)
8-11	0.150 (0.07)	0.149 (0.08)	0.139 (0.06)
$\geq$12	0.151 (0.09)	0.150 (0.08)	0.143 (0.06)
Gender			
Male	0.149 (0.08)	0.151 (0.08)	0.138 (0.06)
Female	0.150 (0.08)	0.147 (0.08)	0.141 (0.06)
Country of birth			
United States (not including Puerto Rico)	0.148 (0.08)*	0.147 (0.08)	0.137 (0.06)*
Mexico	0.153 (0.08)	0.152 (0.08)	0.144 (0.06)
Place child was born or lived during 1st year of life			
Farm/rural/village	0.157 (0.08)*	0.155 (0.08)	0.144 (0.06)*
City or town	0.149 (0.08)	0.148 (0.08)	0.139 (0.06)
Family history of asthma or allergies			
Yes	0.148 (0.08)	0.153 (0.08)	0.141 (0.06)
No	0.150 (0.08)	0.150 (0.08)	0.140 (0.06)
Number of siblings			
$\geq$3	0.150 (0.08)	0.150 (0.08)	0.141 (0.06)
1-2	0.149 (0.08)	0.152 (0.08)	0.138 (0.06)
None	0.137 (0.09)	0.134 (0.10)	0.126 (0.09)
Child ever breast-fed			
Yes	0.150 (0.08)	0.152 (0.08)*	0.142 (0.06)*
No	0.147 (0.08)	0.144 (0.08)	0.133 (0.08)
Current exposure to cats and/or dogs			
Yes	0.159 (0.08)*	0.155 (0.08)*	0.143 (0.05)*
No	0.149 (0.08)	0.149 (0.08)	0.139 (0.06)
Smoker present in the home at the time of child's birth			
Yes	0.147 (0.08)	0.141 (0.08)	0.135 (0.05)
No	0.150 (0.08)	0.151 (0.08)	0.141 (0.06)
Current smoker present in the home			
Yes	0.148 (0.08)	0.144 (0.08)	0.135 (0.07)
No	0.150 (0.08)	0.150 (0.08)	0.141 (0.06)
Proximity to traffic			
$\leq$250 m	0.161 (0.04)*	0.156 (0.05)	0.135 (0.03)
>250 m	0.148 (0.09)	0.146 (0.08)	0.141 (0.07)

IQR, interquartile range; NDVI, normalized difference vegetation index

*$p \leq 0.05$.

Table 3: Unadjusted and adjusted associations[†] of NDVI with respiratory outcomes among all children (*n*=1,915).

Respiratory outcome	**100 m**	**250 m**	**500 m**
	OR[†] (95% CI)	**OR[†] (95% CI)**	**OR[†] (95% CI)**
Lifetime asthma			
Model 1[a]	0.93 (0.75, 1.16)	1.01 (0.79, 1.23)	1.00 (0.82, 1.22)
Model 2[b]	0.91 (0.71, 1.16)	1.01 (0.78, 1.31)	1.03 (0.83, 1.28)
Model 3[c]	0.95 (0.73, 1.23)	1.08 (0.82, 1.42)	1.10 (0.87, 1.39)
Lifetime wheezing			
Model 1[a]	0.82 (0.71, 0.95)*	0.91 (0.78, 1.06)	0.94 (0.82, 1.07)
Model 2[b]	0.81 (0.69, 0.95)*	0.90 (0.76, 1.07)	0.95 (0.83, 1.10)
Model 3[c]	0.82 (0.69, 0.96)*	0.93 (0.78, 1.12)	0.99 (0.85, 1.15)
Current wheezing			
Model 1[a]	0.88 (0.70, 1.12)	0.98 (0.77, 1.26)	0.99 (0.81, 1.22)
Model 2[b]	0.88 (0.69, 1.13)	0.99 (0.77, 1.29)	1.01 (0.82, 1.26)
Model 3[c]	0.87 (0.67, 1.12)	0.98 (0.74, 1.30)	1.01 (0.79, 1.27)
Current dry cough at night			
Model 1[a]	0.90 (0.73, 1.12)	1.02 (0.81, 1.28)	0.97 (0.80, 1.17)
Model 2[b]	0.88 (0.70, 1.11)	1.01 (0.78, 1.29)	0.98 (0.80, 1.20)
Model 3[c]	0.94 (0.74, 1.21)	1.12 (0.85, 1.47)	1.06 (0.84, 1.34)

CI, confidence interval; NDVI, normalized difference vegetation index; OR, odds ratio

[†] For a one-IQR increase in NDVI.
[a]Model 1: Crude, unadjusted, model.
[b]Model 2: Adjusted for: age; gender; country of birth; place child was born or lived during 1st year of life; family history of asthma or allergies; number of siblings; child attended pre-school or day-care; access to a regular doctor or clinic; child had an ear infection during 1st year of life; child had a viral infection during 1st year of life; child took antibiotics during 1st year of life; child ever breast-fed; current exposure to cats and/or dogs; smoker present in the home at the time of child's birth; current smoker present in the home; and proximity to traffic.
[c]Model 3: Model 2 additionally adjusted for: population density; neighborhood deprivation; percentage of residents who identify as Mexican; and number of total crimes reported in 2004.
*$p \leq 0.05$.

Table 4: Adjusted odds ratios‡ reflecting the effect of a one-IQR increase in NDVI on the odds of lifetime asthma by strata of current exposure to environmental tobacco smoke (*n*=1,915).

	100 m	**250 m**	**500 m**
	OR† (95% CI)	**OR† (95% CI)**	**OR† (95% CI)**
Current smoker **present** in the home	0.43 (0.22, 0.87)*	0.39 (0.18, 0.84)*	0.48 (0.26, 0.90)*
Current smoker **not present** in the home	1.07 (0.81, 1.41)	1.23 (0.91, 1.65)	1.24 (0.96, 1.59)

CI, confidence interval; NDVI, normalized difference vegetation index; OR, odds ratio

†For a one-IQR increase in NDVI.

‡Adjusted for: age; gender; country of birth; place child was born or lived during 1st year of life; family history of asthma or allergies; number of siblings; child attended pre-school or day-care; access to a regular doctor or clinic; child had an ear infection during 1st year of life; child had a viral infection during 1st year of life; child took antibiotics during 1st year of life; child ever breast-fed; current exposure to cats and/or dogs; smoker present in the home at the time of child's birth; proximity to traffic; population density; neighborhood deprivation; percentage of residents who identify as Mexican; and number of total crimes reported in 2004.

*$p \leq 0.05$.

Table 5: Adjusted odds ratios‡ reflecting the effect of ‡ a one-IQR increase in NDVI on the odds of current dry cough at night by strata of exposure to environmental tobacco smoke at birth (*n*=1,915).

	100 m	**250 m**	**500 m**
	OR† (95% CI)	**OR† (95% CI)**	**OR† (95% CI)**
Smoker **present** in the home at the time of child's birth	0.53 (0.31, 0.92)*	0.55 (0.31, 0.98)*	0.55 (0.35, 0.87)*
Smoker **not present** in the home at the time of child's birth	1.08 (0.82, 1.42)	1.32 (0.98, 1.79)	1.27 (0.98, 1.64)

CI, confidence interval; NDVI, normalized difference vegetation index; OR, odds ratio

† For a one-IQR increase in NDVI.

‡Adjusted for: age; gender; country of birth; place child was born or lived during 1st year of life; family history of asthma or allergies; number of siblings; child attended pre-school or day-care; access to a regular doctor or clinic; child had an ear infection during 1st year of life; child had a viral infection during 1st year of life; child took antibiotics during 1st year of life; child ever breast-fed; current exposure to cats and/or dogs; current smoker present in the home; proximity to traffic; population density; neighborhood deprivation; percentage of residents who identify as Mexican; and number of total crimes reported in 2004.

*$p \leq 0.05$.