Children living in areas with more street trees have lower asthma prevalence

Short Title:
Street trees and childhood asthma

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ABSTRACT

Introduction: Childhood asthma prevalence in the US increased by 50% from 1980 to 2000, with especially high prevalence in poor urban communities.

Methods: Asthma prevalence among children ages 4-5 years old and asthma hospitalizations among children less than 15 years old were available for 42 health service catchment areas within New York City. Street tree counts were provided by the New York City Department of Parks and Recreation. We also measured proximity to pollution sources, socio-demographic characteristics, and population density for each area.

Results: Controlling for potential confounders, an increase in tree density of one standard deviation (SD: 343 trees/km2) was associated with a lower asthma prevalence (relative risk [RR]: 0.71 per SD of tree density; 95% CI [confidence interval]: 0.64-0.79), but not asthma hospitalizations (RR: 0.89 per SD of tree density; 95% CI: 0.75-1.06).

Conclusions: Street trees were associated with a lower prevalence of early childhood asthma. Our study does not permit inference that trees are causally related to asthma at the individual-level. The PlaNYC sustainability initiative, which includes a commitment to plant one million trees by the year 2017, offers an opportunity for a large prospective evaluation.

An epidemic of childhood asthma has been documented around the world[1] and within the United States.[2, 3] The exact cause of the increase remains elusive, but prevailing theories cite changes in the environment, indoor and outdoor, and changes in lifestyle as potential causes for the increase in asthma prevalence.[1, 4-6] Racial, ethnic and socioeconomic disparities in asthma are substantial,[7-9] with especially high asthma prevalence in poor urban communities.[10-13] In the US, a disproportionate burden of the recent increase in asthma prevalence has been observed in the inner-cities,[13, 14] contributing to the geographic variation in asthma prevalence. For example, the early childhood asthma prevalence is three times higher in the East Harlem neighborhood of New York City than in the adjacent but comparably affluent Upper East Side neighborhood.[15]

Street trees may explain geographic variation in asthma prevalence within urban environments. Trees may help prevent asthma, either by encouraging outdoor play or through an effect on local air quality. According to the "hygiene hypothesis",[16, 17] urban children exposed to few microbes early in life have an increased risk of developing asthma and atopy. Exposure to air pollution could also contribute to excess asthma in urban areas.[18-20] On the other hand, trees are a source of pollen and may trigger asthma exacerbations among children with atopic asthma.[21]

We conducted an ecological study in New York City with the objective of describing the direction and magnitude of any association between street trees and childhood asthma.

METHODS

The unit of analysis is the United Hospital Fund (UHF) area, originally designed to represent hospital catchment areas, and still used for health statistics reports. The 42 UHF areas range in size from 3 to 67 square kilometers.

Asthma prevalence for 4 and 5 year old children were assessed by the New York City Department of Health (NYCDOH) through school screening in 1999.[15] Asthma hospitalizations among children younger than 15 were obtained from the NYCDOH for the year 1997.[15] Asthma cases or hospitalizations were divided by the number of age-eligible children living in each UHF area to approximate risk.

Data from the 1995 street tree census were provided by the New York Parks and Recreation Department. Census-takers counted street trees along each street segment. Street tree density is the total number of trees on street segments within the UHF divided by land area.

Census data from the year 2000 were used to calculate the percent of residents below the federal poverty line, percent African American, percent Latino, and population density for each UHF area. Population density was calculated as persons per square kilometer. These potential confounders may be related to tree placement decisions and unmeasured asthma risk factors.

We also measured proximity to pollution sources (Toxic Release Inventory sites, stationary point sources, and major truck routes) that have previously been associated with asthma in New York City.[19]. Following the approach of Maantay and colleagues,[19] we defined the areas exposed

to each pollution source, then calculated the proportion of each UHF area that was exposed to one or more pollution source.

Partial and simple Pearson correlation coefficients were calculated for each pair of independent variables. Poisson regression models with robust variance estimates were run in Stata 9.2 (Stata Corp., College Station, TX). Our multivariable models controlled for population density, demographic and socioeconomic characteristics (percent poverty, percent African American, and percent Latino), and proximity to pollution sources.

RESULTS

Street tree density was high in the most densely populated areas and in areas with less poverty, and was negatively correlated with the two measures of asthma burden (Table). Higher street tree density was associated with lower childhood asthma prevalence even after adjustment for potential confounders (including socio-demographic characteristics, population density, and proximity to pollution sources), but the association between street trees and asthma hospitalizations was no longer significant after adjustment.

Table. Correlations among area characteristics, early childhood asthma prevalence, and childhood asthma hospitalizations in New York City

	Street tree density	Population density	Percent poverty	Percent black	Percent Latino	Percent near pollution source	Asthma prevalence	Asthma hospitalizations
Street tree density		0.8094***	-0.4895**	0.1849	0.0760	-0.0451	-0.6619***	0.3242
Population density	0.4953***		0.4025*	-0.2108	-0.1729	0.3420*	0.6536***	-0.2860
Percent poverty	-0.5363***	0.2083		0.3803*	0.5422***	0.1789	-0.2746	0.2515
Percent black	-0.2333	-0.0197	0.4045**		-0.5172***	-0.2188	0.1915	0.3456*
Percent Latino	-0.5235***	0.1207	0.7760***	0.1057		-0.0320	0.2778	0.1433
Percent near pollution source	0.1396	0.5670***	0.3805*	-0.0363	0.2927		-0.1874	0.2572
Asthma prevalence	-0.5448***	0.2630	0.7272***	0.4394**	0.6984***	0.2564		0.5779***
Asthma hospitalizations	-0.3926*	0.2263	0.7495***	0.5575***	0.6486***	0.3440*	0.8276***	

Notes: Partial correlation coefficients, shown above the shaded cells, are adjusted for all other area characteristics shown; simple Pearson correlation coefficients are shown below the shaded cells; characteristics and childhood asthma were assessed for 42 areas throughout New York City between 1995 and 2000
* $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$

Unadjusted estimates suggest that an increase in tree density of one standard deviation (SD: 343 trees/km^2) would be associated with a 24 percent lower asthma prevalence (relative risk [RR]: 0.76 per SD of tree density; 95% CI [confidence interval]: 0.67-0.91) and a 26 percent lower asthma hospitalization risk (RR: 0.74 per SD of tree density; 95% CI: 0.62-0.87). After adjustment for potential confounders, we estimate that the same increase in street tree density would be associated with a 29 percent lower early childhood asthma prevalence (RR: 0.71 per SD of tree density; 95% CI: 0.64-0.79). The association between tree density and asthma hospitalizations was not significant after adjustment (RR: 0.89 per SD of tree density; 95% CI: 0.75-1.06).

DISCUSSION

Areas with more street trees experienced a lower prevalence of early childhood asthma. This association was stronger after adjusting for potential confounders such as population density and proximity to air pollution sources. The inverse association street trees with childhood asthma hospitalizations became non-significant following adjustment for the same potential confounders.

Our cross-sectional and ecological study does not permit inference that trees are causally related to childhood asthma prevalence at the individual level. These observational data may be subject to residual confounding or confounding by unmeasured characteristics. Previous studies of tree density and childhood asthma have not been published to our knowledge, and our results need to be replicated by others. Future studies may be more robust if they are able to measure and control for characteristics of the home environment, such as the presence of allergens.

A natural experiment could demonstrate whether abundant street trees caused the lower asthma prevalence observed in densely-planted neighborhoods. The PlaNYC sustainability initiative (www.nyc.gov/html/planyc2030) includes a commitment to plant one million trees in New York City by the year 2017 and offers an opportunity for a large prospective evaluation. Staged tree planting by neighborhood could help identify the effects of increased tree density on childhood asthma.

WHAT THIS PAPER ADDS

Poor urban areas in the US experience especially high childhood asthma prevalence. While temporal patterns in air quality or pollen counts have been associated with asthma exacerbations, the geographic variation in asthma prevalence within cities has not been adequately explained.

Our findings, while not conclusive, suggest that street trees may play a role in preventing early childhood asthma. These data did not support an association between street trees and childhood asthma hospitalizations. Future work to prospectively evaluate a major tree planting intervention will allow stronger inference as to the effects of nearby trees on childhood asthma prevalence.

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COMPETING INTERESTS

None.

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References

1 Eder W, Ege MJ, von Mutius E. The asthma epidemic. *N Engl J Med* 2006;**355**:2226-35.
2 Evans R, 3rd, Mullally DI, Wilson RW, *et al.* National trends in the morbidity and mortality of asthma in the US. Prevalence, hospitalization and death from asthma over two decades: 1965-1984. *Chest* 1987;**91**:65S-74S.
3 Akinbami LJ, Schoendorf KC. Trends in childhood asthma: prevalence, health care utilization, and mortality. *Pediatrics* 2002;**110**:315-22.
4 Platts-Mills TA, Erwin EA, Woodfolk JA, *et al.* Environmental factors influencing allergy and asthma. *Chem Immunol Allergy* 2006;**91**:3-15.
5 Yang IA, Savarimuthu S, Kim ST, *et al.* Gene-environmental interaction in asthma. *Curr Opin Allergy Clin Immunol* 2007;**7**:75-82.
6 Arruda LK, Sole D, Baena-Cagnani CE, *et al.* Risk factors for asthma and atopy. *Curr Opin Allergy Clin Immunol* 2005;**5**:153-9.
7 Gupta RS, Carrion-Carire V, Weiss KB. The widening black/white gap in asthma hospitalizations and mortality. *J Allergy Clin Immunol* 2006;**117**:351-8.
8 Choudhry S, Seibold MA, Borrell LN, *et al.* Dissecting complex diseases in complex populations: asthma in latino americans. *Proc Am Thorac Soc* 2007;**4**:226-33.
9 Savage-Brown A, Mannino DM, Redd SC. Lung disease and asthma severity in adults with asthma: data from the Third National Health and Nutrition Examination. *J Asthma* 2005;**42**:519-23.
10 Cesaroni G, Farchi S, Davoli M, *et al.* Individual and area-based indicators of socioeconomic status and childhood asthma. *Eur Respir J* 2003;**22**:619-24.
11 Carr W, Zeitel L, Weiss K. Variations in asthma hospitalizations and deaths in New York City. *Am J Public Health* 1992;**82**:59-65.
12 Naleway AL. Asthma and atopy in rural children: is farming protective? *Clin Med Res* 2004;**2**:5-12.
13 Busse WW, Mitchell H. Addressing issues of asthma in inner-city children. *J Allergy Clin Immunol* 2007;**119**:43-9.
14 Matricardi PM, Bouygue GR, Tripodi S. Inner-city asthma and the hygiene hypothesis. *Ann Allergy Asthma Immunol* 2002;**89**:69-74.
15 Asthma Facts, Second Edition. New York: The City of New York Department of Health and Mental Hygiene 2003.
16 Strachan DP. Hay fever, hygiene, and household size. *BMJ* 1989;**299**:1259-60.
17 Ramsey CD, Celedon JC. The hygiene hypothesis and asthma. *Curr Opin Pulm Med* 2005;**11**:14-20.
18 Corburn J, Osleeb J, Porter M. Urban asthma and the neighbourhood environment in New York City. *Health Place* 2006;**12**:167-79.
19 Maantay J. Asthma and air pollution in the Bronx: methodological and data considerations in using GIS for environmental justice and health research. *Health Place* 2007;**13**:32-56.
20 Lin S, Munsie JP, Hwang SA, *et al.* Childhood asthma hospitalization and residential exposure to state route traffic. *Environ Res* 2002;**88**:73-81.
21 Dales RE, Cakmak S, Judek S, *et al.* Influence of outdoor aeroallergens on hospitalization for asthma in Canada. *J Allergy Clin Immunol* 2004;**113**:303-6.