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ASTHMA AND SCHOOL COMMUTING TIME

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Abstract

Objectives—This study examined associations of asthma with school commuting time.

Methods—Time on likely school commute route was used as a proxy for on-road air pollution exposure among 4741 elementary school children at enrollment into the Children's Health Study. Lifetime asthma and severe wheeze (including multiple attacks, nocturnal or with shortness of breath) were reported by parents.

Results—In asthmatic children, severe wheeze was associated with commuting time (odds ratio (OR) 1.54 across the 9-minute 5%-95% exposure distribution; 95% confidence interval (CI) 1.01,2.36). The association was stronger in analysis restricted to asthmatic children with commuting times five minutes or longer (OR 1.97; 95% CI 1.02,3.77). No significant associations were observed with asthma prevalence.

Conclusions—Among asthmatics, severe wheeze was associated with relatively short school commuting times. Further investigation of effects of on-road pollutant exposure is warranted.

Keywords

air pollution; asthma; child; epidemiology; traffic; commuting

INTRODUCTION

An estimated 6.2 million children have asthma in the United States, making it the most common chronic disease in childhood,[1] and rates have increased markedly in developed countries over the past several decades.[2] Asthma morbidity results in impaired quality of life

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for the affected child and other family members and in increased utilization of health services that have large social and economic costs.[3]

An emerging literature suggests that childhood asthma prevalence, incidence and severity are associated with exposure to traffic-related pollution near homes.[4-5] The specific pollutants responsible for these associations are not known, but high concentrations of ultrafine particles and associated gases with high potential for respiratory toxicity[6-8] are emitted in vehicular exhaust. These pollutants decline markedly within 150-300 m of roadways,[9-10] which corresponds to reported spatial variation in risk of childhood asthma.[11-12]

Few studies have examined the association between risk of asthma and on-road commuting exposure to air pollution. Exceedingly high particle number and ultrafine exposures have been found in vehicles and school buses.[13-15] In a recent study in southern California school children with long bus commutes, as much as one third of the total daily particle black carbon exposure was estimated to be due to commuting exposures.[13] The primary determinant of exposure was the type and volume of vehicles immediately in front of the bus.

This study examined the effect of commuting time, a marker for on-road pollutant exposures, on lifetime asthma and asthma severity at study entry in a cohort of the southern California Children's Health Study .[12]

METHODS

Characteristics of this cohort have been described previously.[12] Briefly, 5341 children attending kindergarten and first grade were enrolled during the 2002-03 school year from 45 schools in 13 southern California communities selected to represent the extremes and mixtures of regional pollutant profiles in the region.[16] Parent-completed questionnaires provided home address and information about respiratory illness and risk factors for asthma at study entry. Children with a lifetime history of asthma were identified based on parental response to the question “Has a doctor ever diagnosed this child as having asthma? ” “Don't know” responses were excluded from analysis. Asthma was further characterized as late onset if wheezing first occurred after 4 years of age to correspond to school age. Among the 656 lifetime asthmatic children, severe wheeze during the previous 12 months was defined based on a standardized questionnaire[17] as four or more attacks of wheeze, one or more nights per week of wheeze, or wheeze with shortness of breath so severe as to interfere with speech.

Addresses of homes and schools were geo-coded as described previously.[12] We used a service provided by Mapquest (www.mapquest.com) which estimates the children's commuting time (in minutes) and distance from home to school, using home and school address data. The algorithm calculated optimum travel routes based on the shortest time by measuring distances and assigning appropriate travel speeds on different roadways. A Practical Extraction and Report Language (Perl) program was written to automate the inquiry process for the address pairs by sending requests to and extracting travel time

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response from the Mapquest service. There were 4741 children for whom addresses could be geo-coded and commuting time and distance estimated. Missing information resulted from addresses that were missing, incomplete, did not match a U.S. Postal Service address location, could not accurately be geo-coded, or geo-codes for which the algorithm could not assign a commute time. Of the 600 children who were excluded for these reasons, 240 (40%) lived in a single community with winding streets and long distances between intersections that made it difficult to interpolate accurately to a geo-coded location.

We conducted a cross-sectional analysis based on baseline address and outcome reporting. The odds ratios (OR) for asthma were estimated for categories of increasing commuting time and distance compared to a reference time of less than 2 minutes and 0.52 miles, respectively, using logistic regression. (Time was categorized to approximate the quartile distribution, as the time was available to the nearest integer minute, and distance was categorized by quartile distribution). Effects of continuous time and distance were scaled to the within-community 5%-95% range of the distribution of each (9 minutes and 5 miles, respectively). Separate models were fit for lifetime asthma and late onset asthma. Among children with asthma, we examined the association of commuting time and distance with severe wheeze. All models were adjusted for the child's age, gender, race, and community, for mode of travel to school (car, van, or truck, school bus, and walking or bicycling), and for residential exposure to traffic-related pollutants at each child's residence. This residential exposure was estimated from a line-source dispersion model of traffic volume on nearby non-freeway roadways, distance, wind speed and direction, height of the mixing layer in each community and vehicle NOx emission rates, an exposure we have previously shown to be associated with asthma in this cohort.[12] This exposure was also estimated at each school.[18]

Confounding was evaluated by assessing whether the coefficient of the log odds ratio for exposure changed by more than 15% after adding an additional covariate to the base model. Susceptibility was assessed by modeling the interaction of the potentially susceptible groups (eg. parental asthma) with commuting time on a continuous scale. In sensitivity analyses, the associations with commuting time were adjusted for both school and residential modeled traffic pollution (NOx) exposure in a model in which residential NOx was deviated from the school estimate to create uncorrelated exposure metrics. Adjustment for school traffic-related pollutant exposure was conducted in a mixed effects model with a random effect for school. Statistical significance was defined as 2-sided $P<0.05$ for all analyses, which were performed using the Statistical Analysis System Version 9.0 (SAS Institute, Inc., Carey, North Carolina).

RESULTS

Participants in the analytical data set were 4.4-8.9 years of age (almost all 5-7 years). Most children had short commutes to school (median time 3 minutes, interquartile range (IQR) 3 minutes, range <0.5 to 44 minutes; median distance 0.98 miles, IQR 1.43 miles, range 0.01-47.8 miles).

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There were no statistically significant associations of asthma prevalence with commute time (Table 1). However, among 656 children with any lifetime history of doctor-diagnosed asthma, severe wheeze (N=202) was associated with commuting time (OR 1.54 per 9-minute commute; 95% CI 1.01, 2.36). This association was not substantially changed by adjustment for pets and pests at home, parental education, housing characteristics, language of questionnaire, parental asthma, allergy (hay fever or runny nose or itching, watery eyes) in the child, health insurance, body mass index, history of *in utero* tobacco smoke exposure or by traffic-related pollutant exposure modeled for the school address. Sex, history of allergy, of parental history of asthma or parental levels of stress (as previously defined[19]) did not significantly increase susceptibility to commuting time exposure. The association was similar in analyses excluding the 53 asthmatic children who walked to school (results not shown). The patterns of association with distance to school (which was highly correlated with time to school) were generally similar to the effects of commuting time (results not shown).

DISCUSSION

Increasing commuting time to school was associated with severe wheeze among children with asthma. There were no significant associations of asthma prevalence with school commuting time. However, the latency time for the development of asthma related to school commuting would have had to be quite short, as some children had been attending school for less than a year.

Residential traffic-related exposure has been associated with increased asthma severity,[5] and on-road and residential exposure have been associated with other acute outcomes.[20-21] Because most children had short school commute times, we examined the association of commute time with severe wheeze among the 34% of asthmatic children with commuting time 5 minutes or longer. There were larger effects in this group with potentially larger and more biologically relevant exposures (OR 1.97 per 9 minutes (95% confidence interval (CI) 1.02, 3.77), compared with 1.32 (95% CI 0.16, 10.8) among those with commute times less than 5 minutes. Nevertheless, there is considerable uncertainty to the interpretation of these results. Only 5% commuted more than 12 minutes. Therefore, the exposures during the school commute would have had to be large to plausibly account for the relatively large increase in severe wheeze across the range of commute times. Commuting time and distance to school are likely to have been relatively crude estimates of pollutant exposures that depend on traffic volume on the roadways traveled, vehicle emission factors and meteorological conditions. We made no measurements to assess the levels of exposure. It is also possible that a longer commute to school was a proxy for other commuting the child may have done. There was uncertainty as to the true temporal sequence of exposure and health outcome, as this was a cross-sectional analysis. The loss of participants from the analysis due to inability to geo-code addresses necessary for the estimation of commuting time might have resulted in bias that could have explained our results. Children without commuting time were somewhat more likely to be Hispanic, less likely to have health insurance, and more likely to have a responding parent with less than high school education (Table 2). However, adjusting for these factors (or for other likely confounders) had little influence on the effect of commuting on severe wheeze among asthmatic children. It is

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possible that residual confounding may have explained the observed association with commuting time.

Asthma is a clinical syndrome with no sensitive and specific diagnostic test available to confirm clinical assessments. Because of the clinical nature of the assessment, the reported physician diagnosis of asthma we used has been recommended and widely used as a method to classify asthma status in epidemiologic studies, although this approach has limitations.[17, 22] Access to care and differences in practice among physicians has the potential to influence asthma diagnosis.[23] However, adjustment for factors that mediate access to care including family income, parental education, and having medical insurance did not confound the results, indicating that differential access to care was unlikely to explain the observed results.

Traffic exposure during school commuting and asthma are both common among children. Therefore, further investigation of the effects of commuting exposures is warranted, as the public health impact is potentially large.

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Table 1

Association of asthma and wheeze with automobile commuting time from home to school[1]

	<2 minutes[2,3] OR (95% CI)	[2,3) minutes[3] OR (95% CI)	[3,5) minutes[3] OR (95% CI)	≥5 minutes[3] OR (95% CI)	per 9 minutes OR (95% CI)
Lifetime Asthma	1.00	0.98 (0.74, 1.31)	1.09 (0.82, 1.45)	1.15 (0.86, 1.53)	1.03 (0.84, 1.28)
Onset age 4+ years[4]	1.00	1.13 (0.55, 2.34)	1.65 (0.81, 3.33)	1.89 (0.92, 3.88)	1.31 (0.84, 2.03)
Severe wheeze[5]	1.00	1.15 (0.62, 2.16)	1.38 (0.73, 2.58)	1.51 (0.81, 2.82)	1.54 (1.01, 2.36)

[1] All models adjusted for age, sex, race, community, mode of travel to school and modeled residential traffic-related pollution

[2] Reference group <2 minutes for categories

[3] For lifetime asthma the denominator was 942 (19.9%), 1107 (23.3%), 1257 (26.5%), 1435 (30.3%) for <2, [2-3), [3-5), ≥5 minutes respectively; for severe wheeze analysis restricted to the 656 children with asthma., total exposed was 108 (16.5%), 140 (21.3%), 186 (28.4%), 222 (33.8%), for <2, [2-3), [3-5), ≥5 minutes respectively

[4] N=105 with onset of wheeze after age 4

[5] Restricted to 656 children with asthma; N=202 with severe wheeze

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Table 2

Comparison of socio-demographic characteristics of children with and without information on commuting time to school

	Study Population (N=4,741)[1]	Excluded from the study (N=600)[1]
Characteristic	**N* (%)**	**N (%)**
Race/ethnicity		
Hispanic white	2630 (55.7)	368 (62.1)
Non-Hispanic White	1669 (35.4)	195 (32.9)
Black	201 (4.3)	18 (3.0)
Other	220 (4.6)	12 (2.0)
Gender		
Female	2298 (48.5)	283 (47.2)
Male	2440 (51.5)	317 (52.8)
Parental Education		
Less than high school	980 (21.7)	180 (32.7)
At least High School	879 (19.4)	129 (23.4)
Some College	1724 (38.1)	172 (31.2)
College and above	944 (20.8)	70 (12.7)
Health insurance		
Yes	3985 (87.9)	453 (81.9)
No	550 (12.1)	100 (18.1)

[1] Numbers may not add up to the total in some subgroups due to missing data