

Living Near a Main Road and the Risk of Wheezing Illness in Children

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The effect of road vehicle traffic pollution on asthma is still not clearly understood. However, any effect is likely to be most marked among those who live within 150 m of a main road, because this is the distance within which concentrations of primary vehicle traffic pollutants are raised above ambient background levels. We have investigated the relation between proximity of the family home to the nearest main road, estimated objectively using geographical information system software, and the risk of wheeze in the past year in a case-control sample of 6,147 primary schoolchildren (age 4 to 11 yr) and a random cross-sectional sample of 3,709 secondary schoolchildren (age 11 to 16 yr) in Nottingham, United Kingdom. Among children living within 150 m of a main road, the risk of wheeze increased with increasing proximity by an odds ratio (OR) of 1.08 (95% confidence interval [CI] 1.00 to 1.16) per 30-m increment in primary schoolchildren, and 1.16 (1.02 to 1.32) in secondary schoolchildren. Most of the increased risk was localized to within 90 m of the roadside. Among primary schoolchildren, effects were stronger in girls than boys ($p_{\text{interaction}} = 0.02$). Living within approximately 90 m of a main road is associated with a proximity-related increase in the risk of wheezing illness in children.

Keywords: asthma; wheezing; children; vehicular emissions

Motor vehicle emissions are a major source of outdoor pollution throughout the world and there is widespread public concern over their effect on asthma, particularly among children. We have previously reported that average traffic activity in the vicinity of schools in Nottingham (1 km² surrounding area) is not a major determinant of the risk of asthma in children attending those schools (1), but this may be due to the fact that substantial differences in average traffic flows in 1 km² districts do not necessarily translate into equivalent differences in personal exposure to pollution. Data for the main vehicle exhaust pollutants (oxides of nitrogen, carbon monoxide, particulates, and hydrocarbons) indicate that the major contrasts in pollution levels exist near roads, being very high at the roadside and decreasing exponentially with distance from the curbside to reach a plateau by approximately 150 m (2). It therefore follows that increased exposure to vehicle exhaust emissions is likely to occur in those children who live, or spend a large proportion of time, within approximately 150 m of a busy road. Furthermore, we might expect any effect of proximity to a main road on asthma to follow an exposure-response relation within this distance range. Some previous studies have suggested that respiratory morbidity may be increased in children who live within 100 m of a main road (3),

or on a busy road relative to a quiet road (4–7), and one study has reported similar findings in adults (8). However, the evidence is not all consistent (9–11), possibly because some of the studies reporting a relationship have relied on potentially biased self-reported measures of exposure (5–7). Also, those studies that have used objective estimates of distance from roads have analyzed these estimates categorized into binary measures, and as a result the nature of the exposure-effect relationship with increasing proximity of residence to road vehicle traffic remains undefined.

We have therefore used objective spatial analysis techniques in a geographical information system (GIS) to investigate the relation between proximity of the home to the nearest main road and wheezing in primary and secondary schoolchildren in Nottingham, United Kingdom, and in particular, to characterize the nature of this relation within the approximate 150 m range in which pollutant levels are increased. Because several previous studies have suggested that the effects of road traffic pollution on respiratory morbidity may be greater in girls than in boys (3, 4, 12, 13), we have also looked for evidence of a difference in the effects of proximity to major roads on the risk of wheezing in girls and boys in the present study.

METHODS

In 1995 and 1996 we surveyed respiratory symptoms in schoolchildren living in and around Nottingham, for a study of local school traffic density effects on asthma (1), using parental questionnaires for primary schoolchildren (age 4 to 11 yr) (14), and self-completion questionnaires in secondary schoolchildren (age 11 to 16 yr) (15). For the present study we used more detailed data collected on respiratory symptoms, lifestyle factors, and residential postcode (exact addresses were not collected) by parental questionnaire in a nested case-control sample of the primary schoolchildren and a random one-in-four subsample of secondary schoolchildren (1). The primary outcome variable in both groups was parent-reported wheeze in the past year.

Distance from the child's home to the nearest main road (motorway, A or B class road) was computed using GIS software (PC ArcInfo, version 3.5; Environmental Research Systems Institute Inc. Redlands, CA). Home postcodes in the U.K. refer to an average of 15 adjacent houses, and we used grid references of 1-m resolution representing the midpoint of each postcode (Ordnance Survey, Southampton, UK) as an estimate of location for each house. We used ArcInfo to link these to a 0.1-m resolution digitized map of all main roads in Nottinghamshire (Meridian digitized road data, version 2.0; Ordnance Survey, Southampton, U.K.), and to compute the shortest distance between each home location and the nearest main road in meters.

The effect of distance from the road on the odds of wheeze was analyzed using logistic regression (SPSS version 7.5; SPSS Inc., Chicago, IL) initially across the full range of distances in quartiles, and then among those living within 150 m of a main road (approximately the lowest quartile of distance) in 30-m intervals. Potential confounding by age, sex, preterm birth, birth weight, maternal age, maternal smoking during pregnancy, parental smoking in infancy, current parental smoking, month of birth, duration of breast-feeding, birth order, and social deprivation was assessed, and odds ratios (OR) adjusted for age, sex, and those variables found to be independently associated with wheeze in the group are presented. Our primary measure of social deprivation was the Carstairs Deprivation Score (16), computed by residential area from 1991 census data, although we also

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explored adjusting for an individual-based measure of deprivation computed from parental occupation. In the secondary schoolchildren we controlled for the age–sex interaction previously reported in this dataset (15). To look for effect modification by sex, a sex–distance interaction term was added to the model.

Our sample sizes provided more than 80% power to detect ORs for the nearest quartile relative to the farthest of 1.25 for primary schoolchildren and 1.4 for secondary schoolchildren, and for those living within 150 m of a main road, 80% power to detect ORs for the closest relative to the most distant 30-m interval of 1.55 for primary groups and 2.05 for secondary groups.

The study was approved by the Nottingham Director of Education and Nottingham City Hospital Ethics Committee.

RESULTS

Primary Schoolchildren

Of the 6,576 primary schoolchildren in the case-control sample (78% of those eligible for inclusion), we were able to georeference 6,147 (93%, Table 1). In this full sample, quartile of distance of the home from a main road was not significantly related to wheeze (OR = 1.02, 0.90, and 0.97 for the first three quartiles relative to the farthest, $p = 0.36$) and there was no evidence of a trend across the quartiles ($p_{\text{trend}} = 0.97$) either before or after adjustment for potential confounders. However, in the 1,541 children living within 150 m of a main road there was a trend toward an increase in risk of wheeze with increasing proximity to the road, which after adjustment for age, sex, and other risk factors for wheeze in this group (Carstairs Score and preterm birth) was of borderline significance (adjusted OR per 30-m increment = 1.08, 95% confidence interval [CI] 1.00 to 1.16, $p_{\text{trend}} = 0.06$). A plot of adjusted ORs for each distance category demonstrates that most of this effect occurred within 90 m of roadside (Figure 1). There was a significant interaction with sex ($p = 0.02$), such that the effect of distance was strong in girls (adjusted OR per 30-m increment = 1.17, 95% CI 1.05 to 1.31), but absent in boys (adjusted OR = 0.99, 95% CI 0.89 to 1.10, Figure 2). When adjustment was made for social class based on parental occupation rather than Carstairs Score, the magnitudes of these ORs were mildly reduced (adjusted OR per 30-m increment = 1.14 [95% CI 1.01 to 1.28] in girls and 0.98 [0.87 to 1.09] in boys).

Secondary Schoolchildren

Of the 3,880 secondary schoolchildren in the cross-sectional sample with a completed parental response to the wheeze variable (59% of those selected for inclusion), we were able to georeference 3,709 (96%) (Table 1). Some heterogeneity between the quartiles of distance was identified (OR = 0.93, 1.09, and 0.74 for the first three quartiles relative to the far-

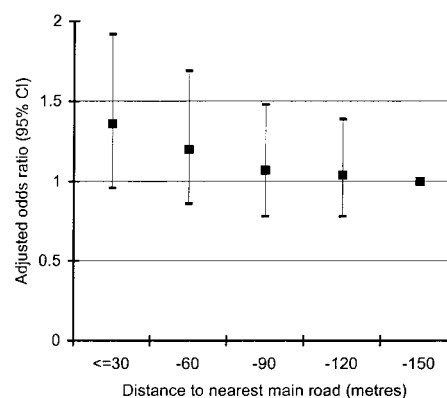


Figure 1. Exposure–response relation between distance of the home from nearest main road and parent-reported wheeze in primary schoolchildren.

thest, $p = 0.02$), but with no obvious trend ($p_{\text{trend}} = 0.68$), either before or after control for potential confounding. However, in those 859 children living within 150 m of a road, there was a positive association between the risk of wheeze and proximity to the roadside, which remained statistically significant after adjustment for other risk factors for wheeze in this group, age, sex, age–sex interaction, Carstairs Score, preterm birth and maternal smoking in infancy (adjusted OR per 30-m increment = 1.16, 95% CI 1.02 to 1.32, $p_{\text{trend}} = 0.03$). The greatest increase in risk occurred within 60 m of the roadside (Figure 3). Slightly stronger effects were seen among secondary school girls than boys (adjusted OR per 30-m increment = 1.19 [95% CI 0.99 to 1.43] for girls and 1.13 [0.94 to 1.36] for boys), but this interaction was not statistically significant ($p = 0.65$). Substituting social class based on parental occupation in place of Carstairs Score in the model resulted in similar findings (adjusted OR per 30-m increment = 1.14, 95% CI 1.00 to 1.31). Associations of similar magnitude were identified in this cross-sectional group for cough and diagnosed asthma (adjusted OR per 30-m increment = 1.12 [95% CI 0.98 to 1.28] and 1.15 [0.97 to 1.38] respectively), but there was no relation between proximity to roadside and eczema or hay fever.

DISCUSSION

This study provides evidence that the risk of wheeze in children is increased in relation to proximity to main roads, as might be expected from the profile of traffic pollutant levels close to the road (2), and that this increase in risk applies primarily to those living less than approximately 90 m from the roadside. This suggests that adverse effects of road vehicle pollution are relatively localized, and may explain previous observations by us (1) and others (5, 17) that traffic activity in the wider locality of school or home, in contrast to activity within about 90 m, is not a major determinant of respiratory morbidity.

We used objective estimates of distance between the home and the nearest classified or numbered road, which at the time of the study in the Nottingham area typically carried between 10,000 and 100,000 vehicles per day, as a marker of exposure to the mix of pollutants arising from exhaust emissions. Although this measure of distance is objective and therefore free from reporting bias, it is still an approximate estimate of exposure because individual exposure is also likely to be influenced by the volume and flow of traffic on the road, by the amount of time spent at home, and by the presence of physical obstructions between the road and the home. Also, the postcode

TABLE 1. CHARACTERISTICS OF PRIMARY AND SECONDARY SCHOOL SAMPLES

	Primary School Case-control	Secondary School Cross-sectional
Number in sample	6,576	3,880
Number (%) georeferenced	6,147 (93%)	3,709 (96%)
Of which:		
number (%) boys	3,204 (52%)	1,805 (49%)
number (%) wheeze in past year	2,483 (40%)	608 (16%)
median distance to main road, m	321	372
interquartile range of distance, m	149–700	163–742
number (%) living ≤ 150 m from main road	1,541 (25%)	859 (23%)
number (%) living ≤ 30 m from main road	214 (3.5%)	125 (3.4%)

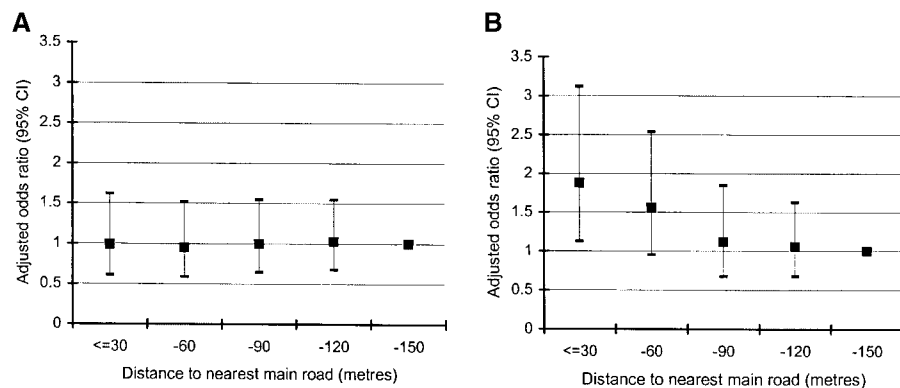


Figure 2. Exposure-response relation between distance of home from nearest main road and parent-reported wheeze in primary (A) boys and (B) girls.

references we used apply to groups of about 15 adjacent houses and therefore will have resulted in some misclassification. However, this misclassification is not systematic and will therefore only reduce the magnitude of our estimates of effect. We were unable to estimate home location more precisely because we did not have exact home addresses available to us. We chose parent-reported wheeze in the past year as our primary outcome variable to avoid the diagnostic and labeling biases inherent in a diagnosis of asthma, and for consistency between the two school groups, though data on other parent-reported respiratory disease markers available in the secondary schoolchildren provided consistent findings. Although the possibility of response or reporting bias in parents of those living on main roads cannot be ruled out, parents were not aware of the hypothesis being tested, and such bias is also unlikely to explain the clear difference in effect between the sexes in primary schoolchildren.

Two previous studies have shown associations between objective measures of proximity to main roads and respiratory symptoms consistent with our findings in children (3, 4), as has one study in adults (8). Other studies have failed to find an effect on treated asthma (9), or hospital admission for asthma (10, 11), but these used larger distances to define a binary measure of proximity to a main road. Oosterlee and coworkers reported a 50% increase in wheeze in the past year among Dutch children living on a busy street relative to living on a quiet street (4), and another study of Dutch children reported a doubling of wheeze prevalence in children living within 100 m of a freeway (3), but no effect on lung function (12). Both studies reported larger estimates for girls than boys, and a similar predominance in girls has been reported for associations between truck traffic density and lung function (12), nitrogen dioxide exposure and wheezing bron-

chitis (13), and passive exposure to tobacco smoke and bronchial responsiveness (18). In the light of these previous observations, we looked for differences in effect between sexes and found significant evidence of a greater effect in primary, but not secondary girls. Why girls appear more susceptible to the impact of pollution than boys is unclear.

The consistency of our findings between the two independent datasets, and the exposure-response association within the distance over which concentrations of the main primary pollutants arising from vehicle exhaust emissions are known to be increased, support a causal effect of exposure to road traffic pollution on wheezing illness in children. If true, this has important health implications for the minority of the population (approximately 12% in the Nottingham area) who live within about 90 m of a main road. Further work is now required to determine which specific pollutant or pollutants are likely to be responsible, why girls appear to be more susceptible than boys, and the extent to which risks of cardiovascular and other pollution-related disorders are also increased in relation to this exposure in children and adults.

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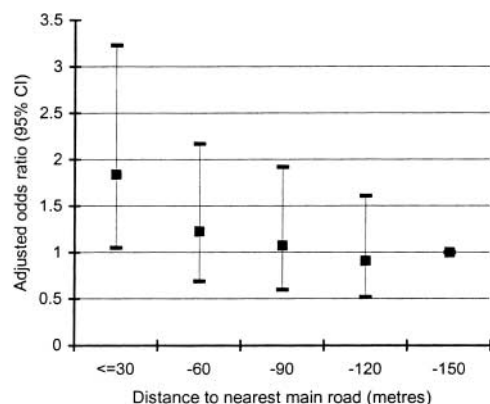


Figure 3. Exposure-response relation between distance of home from nearest main road and parent-reported wheeze in secondary schoolchildren.

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