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Predicting residential ozone deficits from nearby traffic

Rob McConnell [a,*], Kiros Berhane [a], Ling Yao [a], Frederick W. Lurmann [b], Edward Avol [a], John M. Peters [a]

[a] *Department of Preventive Medicine, Keck School of Medicine at the University of Southern California, 1540 Alcazar Street, CHP 236, Los Angeles, CA 90089, United States*
[b] *Sonoma Technology, Incorporated, 1360 Redwood Way, Suite C, Petaluma, CA 94954, United States*

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Abstract

Oxides of nitrogen in fresh traffic exhaust are known to scavenge ambient ozone. However, there has only been little study of local variation in ozone resulting from variation in vehicular traffic patterns within communities. Homes of 78 children were selected from a sample of participants in 3 communities in the southern California Children's Health Study. Twenty-four hour ozone measurements were made simultaneously at a home and at a community central site monitor on two occasions between February and November 1994. Homes were geo-coded, and local residential nitrogen oxides (NO_x) above regional background due to nearby traffic at each participant's home were estimated using a line source dispersion model. Measured home ozone declined in a predictable manner as modeled residential NO_x increased. NO_x modeled from local traffic near homes accounted for variation in ozone concentrations of as much as 17 parts per billion. We conclude that residential ozone concentrations may be over- or underestimated by measurements at a community monitor, depending on the variation in local traffic in the community. These findings may have implications for studies of health effects of traffic-related pollutants.

Keywords: Ozone; Oxides of nitrogen; Vehicle emissions; Photochemistry

1. Introduction

There is an extensive literature describing how ozone varies on a regional scale as a function of sources of upwind ambient NO_x, reactive organic gases, and atmospheric photochemistry, and models have been developed to predict downwind ozone concentrations in communities without monitoring stations (National Research Council Committee on Tropospheric Ozone Formation and Measurement, 1991; Diem and Comrie, 2002). However, a recent critique of ozone mapping efforts noted that interpolations from central site monitors to local neighborhoods are not justified by the spatial resolution of available data and have not been validated against the dense network of measurements that would be required to justify the assumption that the

* Corresponding author. Tel.: +1 323 442 1096; fax: +1 323 442 3272.
E-mail address: rmcconne@usc.edu (R. McConnell).

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distribution of ozone is homogeneous within communities (Diem, 2003). Where monitoring sites have been available in close proximity in urban areas, levels have differed by up to 50% within 5 km of each other (McNair et al., 1996).

One reason for the spatial inhomogeneity of ozone is local variation in traffic, because nitric oxide (NO) present in fresh vehicle exhaust reacts with and consumes ozone. This reaction occurs much more rapidly than the atmospheric photo-oxidation that produces ozone regionally. Thus, ozone is reduced in tunnels, in heavy traffic, and near heavy traffic corridors, compared with nearby fixed site measurements near the traffic corridor (Rodes and Holland, 1981; Chan et al., 1991). Ozone concentrations are generally lower in urban cores with heavy traffic, compared with downwind suburban areas with little traffic related NO to react with and consume ozone (National Research Council Committee on Tropospheric Ozone Formation and Measurement, 1991; Diem and Comrie, 2002; Gregg et al., 2003). In one previous study, concentrations 8 m downwind from a freeway were often less than 10% of background ambient levels, and reduction in ozone concentrations were evident to 500 m (Rodes and Holland, 1981). Although this local variation in traffic is known to modify ozone concentration (Liu et al., 1997; Monn, 2001), there has been little attempt to exploit complex variation in traffic on freeways, arterials, and collector streets within neighborhoods to predict ozone exposure at homes, predictions which would be useful for health studies. Grid-based photochemical air quality models typically have K-theory dispersion algorithms that are not suitable for applications with the fine horizontal resolution (e.g., <200 m) needed to simulate line-source impact (Seinfeld and Pandis, 1998).

We investigated whether local variation in measured residential ozone in southern California could be predicted based on traffic related oxides of nitrogen (NO_x) at the home. NO_x from local traffic were estimated from traffic counts available from the California Department of Transportation.

2. Data and methods

We used an existing data set of ambient ozone measured at homes in southern California and of concurrent measurements of ambient ozone and NO_x at community central site monitors (Avol et al., 1998). Residential NO_x concentrations outside study homes were estimated for our analysis from traffic patterns near the homes, as described below. We examined the relationship between home ozone and residential traffic-related NO_x, after adjusting for simultaneously measured central site ozone and NO_x. Based on this regression, we estimated residential ozone at other homes in the community.

Homes of 78 children were selected from a sample of participants in the Children's Health Study (Peters et al., 1999). Details of the study population for this residential ozone study and the sampling protocol have been reported previously (Avol et al., 1998). Briefly, ozone was measured between February and December during 1994 immediately outside homes in the southern California communities of Lancaster, San Dimas, and Riverside. A controlled flow sampler, which permitted timed exposure diffusion sampling with an Ogawa sampler, was developed for use in this study. Nitrite-coated filters from Ogawa USA (Pompano Beach, FL) were loaded onto Teflon-filter holders in an ozone-free environment. Before and after sampling, filters were stored under conditions designed to minimize ozone exposure. These passive samplers were placed on the rear patio or porch at least 1 m above the ground, but avoiding tree canopies, roof overhangs, and home air vents. Sampling was conducted during 24 h at each study home on two occasions, once in the spring and once in late summer/early fall. In previous evaluations (Koutrakis et al., 1993) and in this study in co-located field sampling at 5 homes and in laboratory comparisons with a continuous ultraviolet photometer (Dasibi Model 1003-AH, Glendale, California) (Lurmann et al., 1994; Avol et al., 1998), the timed exposure diffusion sampling results were found to be comparable to within approximately 6%.

During each 24-hour home ozone measurement, background ambient ozone was interpolated to the neighborhood of each study home from measurements at nearby air monitoring stations, typically located within a few kilometers of study homes. These measurements were made for comparison to each home measurement. Ambient background NOx_x in each community was measured at the nearest station. These measurements were made with ultraviolet

ozone photometers and chemiluminescent NOx monitors operated under prescribed regulatory air monitoring protocols and procedures.

NO_x levels above ambient background were estimated from traffic patterns in the vicinity of each home. Each address was standardized to United States Postal Service specifications, using Lorton Data (www.lortondata.com) and geo-coded using the Tele-Atlas online geocoding service. Average annual daily traffic volumes on freeways, arterials, and collectors in each community were obtained from the California Department of Transportation for 2000 and adjusted to reflect 1994 traffic volumes, based on 3% per year growth in Southern California (CalTrans, 2002). The roadway locations were also based on the Tele-Atlas roadway database. Fleet average vehicle emission factors for NO_x in 1994 were obtained from the California Air Resources Board's EMFAC2002 model (California Air Resources Board, 2002). The ambient concentrations of NO_x from on-road vehicle emissions on roadways within each community were estimated at each residence using the CALINE4 line source dispersion model developed by the California Department of Transportation (Benson, 1989). The modeling region for each community was a 20 km by 20 km region encompassing the residences wherein the CALINE4 model estimated unique concentrations at each geocoded residence location with 10–20 m spatial resolution. These concentrations should be regarded as incremental NO_x contributions that result in local variation on top of background concentrations of ambient NO_x (measured at the central site in each community). We refer to these modeled estimates as residential NO_x to distinguish them from measured central site NO_x measurements. Background ambient NO_x results from regional transport and photochemistry on an urban and regional scale. Thus, local traffic influences the relatively homogeneous background regional NO_x concentrations downwind from these local traffic sources and also influences middle-scale and neighborhood-scale variations immediately adjacent to roadways and in the nearby neighborhood. We elected to use the modeled concentration of NO_x for this study, because NO in fresh traffic exhaust is rapidly converted to NO_2, as it mixes and reacts with background ozone,, and the modeled incremental contribution of traffic to NO_x concentration disperses rapidly from the source. Thus, modeled incremental NO_x is expected to reflect NO in fresh traffic exhaust available to react with ozone, and if so, should predict decreases in ozone within communities relative to the central site monitor.

Line source dispersion models like CALINE4 have primarily been evaluated for short-term (1 h) estimates of carbon monoxide concentration, where the CALINE4 model has shown it is able to predict 1-h concentrations within a factor of two (−50 to +100%) in 80% of cases (Benson, 1989). We have evaluated the CALINE4 model's performance for long-term NO_x from local traffic at 12 southern California locations (see Fig. 1). The model's annual predictions were highly correlated ($R^2=0.97$) with the 4-year average concentrations observed at routine air monitoring sites, yet the model underestimated the observed concentrations since they included the regional background NO_x. The CALINE4 model estimates suggest local traffic contributions constitute 18% of NO_x concentrations in these communities.

An additional community in the original study, Lake Gregory, was excluded from the analysis reported here, because there was little traffic (Avol et al., 1998). Seven other homes were excluded from the analysis, because there were incomplete ambient central site NO_x measurements during the day of sampling. In addition, in the original study, indoor ozone was measured at homes, using a sampler identical to that described above. Two homes were excluded because indoor ozone was unexplainably greater than outdoor ozone. (Because there are generally no indoor sources of ozone, and ozone is scavenged indoors, indoor levels of ozone are virtually always values lower than outdoor values). One other outlier was excluded from the analysis, because outdoor home ozone was more than 3 standard deviations from the mean and was inexplicably high with respect to the central site monitor. Seventy-eight homes were included in the final analysis.

Because there were two measurements at each home, we needed to account for the correlation between the repeated measures from the same subject. We used the Generalized Estimating Equations (GEE) approach (Diggle et al., 1994) to investigate the effects of estimated residential NO_x from the CALINE4 model on outdoor residential ozone. Under this approach, the interpretation of parameter estimates is identical to that in standard multiple linear

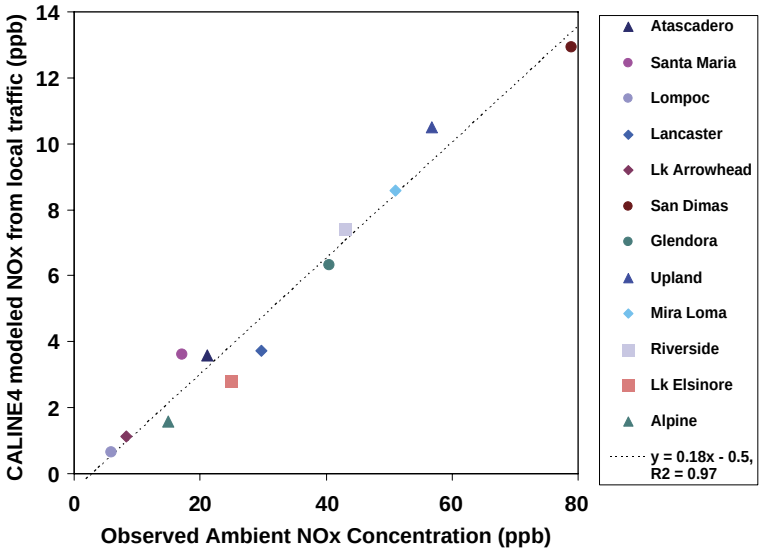

Fig. 1. Comparison of annual average CALINE4 model estimated NO_x concentrations from local traffic to 1995–1998 average NO_x concentrations observed at 12 air monitoring stations in southern California.

regression, but it has the advantage of providing correct standard errors (which would have been underestimated otherwise). The assumptions for the GEE based model are similar to those in standard multiple linear regression. The following final model was fitted:

$$Y_{cij} = \alpha + \delta^T Z_{cij} + \gamma_1 \mathrm{CS\_Ozone}_{cij} + \gamma_2 \mathrm{CS\_NO}_{x\ cij} + \gamma_3 \mathrm{NO}_{x\ cij} + \varepsilon_{cij}. \quad (1)$$

Where Y is ozone (measured at home), c, i and j denote community, individual home, and visit, respectively. Here, α represents the overall intercept and δ represents a vector of parameters of effects of a matrix of adjustment variables, Z_{cij} (e.g., visit, community). The parameter of main interest was γ_3, the effect of residential NO_x levels, $NO_{x\ cij}$, in a model that adjusted for central site O_3 and NO_x levels, denoted by CS_Ozone_{cij} and $CS\_NO_{x\ cij}$, respectively. Central site ozone and NO_x measurements were centered at the overall mean of 35.9 parts per billion (ppb) and 44.6 ppb, respectively, in these models. This GEE model was fitted with the identity link and a "working" exchangeable correlation structure. It used "empirical" standard errors that are robust to any misspecification of the nature of dependence between the two repeated measures from the same home.

We assessed how generalizeable the estimates for the effect of residential NO_x might be to other communities by evaluating the effect of NO_x in models without the community indicator variables. We evaluated potential modification of the effect of residential NO_x on residential ozone by community and by visit early or late in the year. Appropriate interaction terms were added to the GEE model to test these hypotheses. A validation of the model consisted of randomly selecting 2/3 of the sample in each community and fitting a model which was then used to predict the observed O_3 in the remaining 1/3 of the sample.

Finally, the predictions from the model were used to examine the possible impact of residential NO_x on long-term residential ozone concentrations at homes of all participants in the Children's Health Study in these 3 communities with addresses that could be accurately geo-coded (449 in Lancaster, 498 in Riverside, and 439 in San Dimas). For this prediction, we used 1994 annual average residential NO_x concentrations derived from CALINE4 at the GIS coded addresses of all study homes and the 1994–1998 average ozone and NO_x concentrations measured at the central site monitors. We also estimated the effect based on a single 1994-year average for the measured central site pollutants. Because the home ozone predictions were very similar, we have presented only the

estimates based on the more stable multi-year pollutant average.

3. Results

Average 24-h ozone measurements were 33 ppb and 34 ppb at the homes and central site monitoring stations, respectively, but there was a large range from 4.5 ppb to over 90 ppb (Table 1). Estimated residential NO_x concentrations modeled from traffic were not normally distributed. The median was 11 ppb, but one home 90 m from a freeway had an estimated NO_x exposure of 35 ppb. Fifty percent of the estimated concentrations were between 6.2 and 16 ppb; and 80% were between 4.3 and 19 ppb (results not tabulated). Lancaster had a much smaller range of modeled NO_x than either of the other two communities. Although these exposures are modest compared with the much larger measured central site NO_x measurements, it is important to note that these were incremental concentrations from traffic near homes *above* any community ambient background levels.

Residential ozone was inversely associated with estimated residential NO_x, decreasing by 0.51 ppb for each modeled increase of 1 ppb in residential NO_x (Table 2). Thus, the range of residential NO_x in this study (2.1–35 ppb from Table 1) was associated with almost a 17 ppb decrease in the ozone measured at those homes (results not tabulated). However, a relatively small proportion of homes near heavy traffic corridors accounted for most of the variation in ozone, and the variation due to traffic at most homes was modest. The 10th to the 90th percentile of the residential NO_x distribution (from 4.3 to 19 ppb) was associated with a 7.5 ppb decrease in home ozone. Home ozone exposure was higher during the first visit (earlier in the year), on average, than on the second visit, after adjusting for central site ozone measurements and other variables in the model (Table 2). Visit was also significant in a model adjusting for season (before May or after October), but the addition of season to the model did not substantially change the effect of NO_x (data not presented). We adjusted for central site NO_x, an indication of more polluted days with stagnant air around roadways, in order to account for potentially larger effects of residential traffic on ozone on those days.

Table 2
Determinants of home ozone concentration

Parameter	Coefficient (in pbb)	(S.E.)	*P* value
Residential NO_x[a]	−0.51	0.11	<0.0001
Central site O_3[a]	0.91	0.05	<0.0001
Central site NO_x[a]	−0.029	0.018	0.10
Riverside	−0.28	1.65	0.86
San Dimas	0.12	2.03	0.95
Visit 1	2.29	1.0	0.03
Intercept	37.7	1.14	<0.0001

[a] Residential NO_x in ppb; central site O_3 and NO_x centered at 40 and 45 ppb, respectively.

The split sample resulted in coefficients derived from 2/3 of the homes similar to those from the entire sample. The coefficient for residential NO_x in 2/3 of the sample was −0.51, for ambient ozone at the central site 0.89, for visit 2.26. Although the power to test this prediction model in the remaining homes was limited by small sample size, the predicted home ozone in the remaining homes was highly correlated with the mea-

Table 1
Concentrations of ozone measured at homes, of ozone and NO_x measured at central sites, and of modeled residential NO_x

Pollutant	Lancaster (*N*=25 homes)		Riverside (*N*=31 homes)		San Dimas (*N*=22 homes)		All communities (*N*=78 homes)	
	Mean (SD)	(min, max)	Mean (SD)	(min, max)	Mean (SD)	(min, max)	Mean (SD)	(min, max)
Home O_3[a]	40 (60)	(6.5, 63)	32 (14)	(9.6, 79)	28 (15)	(4.5, 60)	33 (15)	(4.5, 79)
Central site O_3[a]	39 (13)	(16, 65)	36 (16)	(9.7, 92)	34 (14)	(15, 57)	36 (15)	(9.7, 92)
Central site NO_x[a]	29 (16)	(3.2, 60)	46 (37)	(11, 142)	56 (21)	(26, 103)	45 (30)	(3.2, 142)
	Median (IQR)	(min, max)	Median (IQR)	(min, max)	Median IQR)	(min, max)	Median (IQR)	(min, max)
Residential NO_x[b]	4.8 (1.5)	(2.1, 6.8)	11 (5.8)	(6.2, 35)	16.2 (3.1)	(6.2, 24)	11 (9.7)	(2.1, 35)

[a] Measured 24-h mean (ppb).
[b] Modeled for annual average daily traffic counts.

sured concentration ($R=0.94$; $p<0.0001$). However, this was largely accounted for by the large variability in ozone at the central site, which was highly correlated with home ozone. The residuals from the prediction model excluding residential NO_x were more modestly but still significantly correlated with residential NO_x ($R=-0.43$; $p=0.002$).

We considered whether the prediction model derived from the entire sample could be used to predict ozone at homes in other communities in southern California, based on ambient measurements at a community central site monitor and traffic patterns near homes, exposure indices that are widely available throughout California (and elsewhere in the United States). Our premise was that the atmospheric chemical reactions affecting these relationships and the general nature of vehicle emissions not accounted for in the vehicle emission models (e.g., NO/NO_x ratios) would be similar across many communities. However, this type of statistical model–describing the physical effects of traffic-related NO_x on local ozone–could not be extrapolated to other communities if residential ozone or NO_x were confounded by community, or if the effect of residential NO_x were to vary in different communities, after adjusting for central site measurements and other covariates in the model. None of these conditions occurred in our limited sample of communities: There were no significant effects of community (Table 2); the coefficient for residential NO_x was almost identical in a model that did not adjust for community (data not shown); and there were no significant interactions between residential NO_x and community (that is, the effect of residential NO_x did not differ by study community). The significant effect of visit, an unphysical parameter required in the model, suggests that predicted residential ozone with respect to central site measurements may vary by time of the year or other unmeasured conditions prevalent at the different visits in this study. However, any bias introduced by this effect was unlikely to vary by residential NO_x, because there was no interaction of residential NO_x with visit (data not presented). Although this consideration may make the accuracy of ozone predictions questionable and merits further investigation, it is nevertheless instructive to examine the likely effect of traffic on home ozone concentrations with respect to long-term central site ozone concentrations.

A prediction curve for home ozone across the range of incremental traffic-modeled NO_x observed in this study, in a hypothetical community with measured long-term central site monitoring station average NO_x, CS_NO_x, and ozone, CS_Ozone, has the following form:

$$\text{Home ozone} = 37.7 + 0.919(\text{CS\_Ozone} - 35.9) - 0.029(\text{CS\_NO}_x - 44.6) - 0.51\text{NO}_x \quad (2)$$

where long-term (1994–1998) central site ozone and NO_x measurements were centered at the overall sample mean in our study of 35.9 ppb and 44.6 ppb, respectively. Traffic modeled residential NO_x were estimated from CALINE4 at homes. Visit and community (with visit 2 and Lancaster as references, respectively) should not affect the long-term within-community variability in ozone with respect to the central site, nor should they contribute to the variability in the predicted values with respect to other homes in the community. Based on this prediction equation, we estimated the distribution of residential ozone in the entire cohort of children enrolled in the Children's Health Study in the three communities. We restricted the distribution to homes with residential NO_x values less than 35 ppb, because the behavior of the model at higher residential NO_x (which were as large as 128 ppb in this population) is unknown. In San Dimas and Riverside the predicted range in residential ozone was 15 ppb (Table 3), although the variation from the 10th to the 90th percentile of the distribution in those towns was a more modest 4.5 in

Table 3
Predicted 5-year average home ozone (in pbb) in entire cohort, by community

Town	Predicted 5-year O_3 at homes			NO_x[a] (min, max)	O_3 at C.S.[a]
	Mean	10%, 90%[a]	Min, max		
Lancaster ($N=449$)	33	32, 34	29, 35	0.3, 12	33
Riverside ($N=498$)	27	23, 29	16, 31	4.1, 35	31
San Dimas ($N=439$)	17	14, 19	9, 24	2.8, 33	23

[a] Ozone 10%, 90% corresponds to lower decile and upper decile of the distribution; NO_x (in ppb) corresponds to residential NO_x; O_3 at C.S. was measured at the central site monitor in each community.

San Dimas and 5.8 in Riverside. However, because we truncated the upper distribution of residential NO_x at 35 ppb, lower ozone levels (with a lower limit of zero) might be expected to be observed at homes with higher levels of residential NO_x in these communities.

4. Discussion

There has been little previous research demonstrating the predictable local spatial variability in ozone that we have shown in these study communities as nearby traffic varies. As described above, ozone concentrations at most homes varied by a modest 7.5 ppb or less due to nearby traffic. However, reductions in ozone concentrations of up to 17 ppb were associated with heavy local traffic across the range of estimated residential NO_x in this sample. Our results are consistent with one previous report that demonstrated a 30–40% decrement in ozone as traffic and building density increased at many sites in a neighborhood within 2 km of central monitor (Lin et al., 2001). There are several potential implications of this observation for the evaluation of health effects of traffic and ozone, and potentially for regulatory policy: (1) The interpretation of measurements of ambient ozone at community monitoring stations in southern California and elsewhere may be biased if traffic patterns at homes in the community differ substantially from traffic near the monitoring station; (2) there should be further investigation of ozone variability due to traffic on a neighborhood scale within communities in order to refine models that could be used for assigning ambient ozone exposures at homes for use in epidemiologic studies; and (3) the inverse relationship of ozone to traffic may bias the results of ongoing studies of the health effects of fresh traffic emissions, if potentially confounding health effects of ozone are not appropriately accounted for.

It is well known that measurements of regional pollutants like ozone at central site monitors misclassify personal exposure (Delfino et al., 1996; United States Environmental Protection Agency, 1996). The estimates in Table 3 suggest that there is likely to be systematic spatial variation of average ozone with nearby traffic. The predicted within-community range of 15 ppb in measurement of home ozone concentration is small compared with the large temporal variability shown in Table 1, and the levels are low compared with the current National Ambient Air Quality Standards regulating peak concentrations exceeding 120 ppb for 1 h and 80 ppb for 8 h of the day. However, the long-term average 24 h ozone measured at the central sites was relatively low, even in these study communities with high peak ozone concentration, which were selected to represent diverse southern California ozone profiles. Therefore, the predicted misclassification of ozone exposures at homes could constitute a substantial proportion of the measured long-term ozone exposures at central sites. Because NO from traffic near a central site monitoring station would also reduce the measured ozone at that station, the central site measurements could either under-estimate or over-estimate the average community home ozone exposure, depending on whether nearby traffic at the central site were substantially higher or lower than near homes in the surrounding community. The U.S. Environmental Protection Agency has recommended that regional air pollution monitoring stations be sited away from roads with heavy traffic, and previous work in Los Angeles has demonstrated that ozone concentrations are affected up to at least 500 m of a major roadway (Rodes and Holland, 1981). However, using CALINE4 we have estimated NO_x related to long-term average local traffic to contribute as much as 38 ppb at the central site monitoring station (in Long Beach) used for characterizing exposure in a multi-year longitudinal health study (Peters et al., 1999). Therefore, local traffic around such stations is potentially an important source of error in assigning exposure to an entire community based directly on central-site monitoring station data.

The model presented illustrates how ozone might be predicted at individual homes. There was substantial variability in the ozone measurements at homes and central sites, and there was a large range of nearby traffic at these homes, representative of many communites in southern California and likely in other regions of the United States. However, questions remain regarding this approach that cannot be answered with the available data, and additional measurements over a longer time frame would be useful to model better the long-term variation in ozone exposure at homes. The 24 h ozone varied markedly over the period of the study, so the effect of residential NO_x

explained a relatively small proportion of the variability in residential ozone. A larger proportion of variability in the longer-term average residential ozone might be explained by residential NO_x. Residential NO_x also explained only a modest proportion of measured home ozone based on the split sample approach ($R = -0.43$ for NO_x with the residual after accounting for the effect of central site ozone), although this may be due in part to the small sample size. Also, although the range of variability in residential NO_x was large, there were relatively few homes that accounted for the higher residential NO_x estimates. It would be useful to examine the effect of residential NO_x on ozone at more homes with heavy local traffic to evaluate the stability of observed estimates in areas where more marked reductions in ozone might be expected. Additional measurements in these communities also would help determine the relevance of local traffic patterns for the higher ozone concentrations observed between 10 am and 6 pm (when children and other susceptible groups may engage in more outside activity that would increase exposure).

We observed no difference in the effect of residential NO_x in different communities, using a model that considered only linear effects of residential NO_x (because this model is consistent with the known chemistry of ozone and local sources of NO_x on the neighborhood scale of interest). However, the statistical power to identify interactions was limited. In a sensitivity analysis that used flexible techniqures that relaxed the assumption of linearity (Hastie and Tibshiarni, 1990), we observed some non-linearity in the effect of NO_x that may have reflected differences in the effect in Lancaster, which had much smaller residential NO_x estimates than either of the other two communities. Longer term home ozone and NO_x measurements would allow better assessment of heterogeneity across communities. In addition, there was systematic variability in ozone associated with the measurement at the second visit to the homes, after adjusting for other covariates (Table 2). Because traffic-modeled NO_x estimates using CALINE4 were based on average traffic count estimates and on average wind speed and direction over an entire year, meteorological conditions or traffic patterns that differed on different days of measurement from those used to estimate the long-term average NO_x might explain the effect of visit. However, we observed no evidence for an interaction between visit and residential NO_x, so the effect of residential NO_x on ozone is unlikely to vary by visit. Therefore, to the extent that visit represented unmeasured influences on ozone throughout the community, including at the central site, there may be little bias to the assessment of how a home varies with respect to a central site within a given community, which is the key parameter of interest. This issue requires further study. Finally, estimating long term average effects of residential NO_x on ozone would not be possible in communities in which there is new development with traffic patterns that change in different ways in different parts of the community.

Although uncertainties in the model presented require further assessment, the observed variation in ozone may be important for the design and interpretation of ongoing studies of traffic-related pollution. Heavy local traffic has been associated with deficits in lung function, with asthma and with asthmatic symptoms in children (Brauer et al., 2002; Delfino, 2002). It has been shown that particle number and ultrafine particle mass decrease dramatically to background levels within short distances downwind of freeways (Zhu et al., 2002), and it is biologically plausible that such exposure would cause the observed associations with respiratory health (Li et al., 2003). It is likely that exposure to fine and ultrafine particulate matter and other air pollutants in fresh traffic exhaust increases not just with freeways, but also with nearby traffic on arterial and collector roadways (although there has been little study of this issue). Our results indicate that exposure to these local toxic traffic related pollutants is likely to be inversely correlated with ozone exposure. Therefore, in high ozone communities the assessment of toxic effects of traffic likely also will be confounded by the toxic effects of ozone.

5. Conclusion

This study suggests that traffic patterns near homes are potentially a useful tool to predict local spatial variation in ozone within communities.

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