Given the potential significance of the child care microenvironment for young children’s overall air pollution exposure, there is a need for new insight into the extent to which child care facilities are located in near-roadway areas with potentially high concentrations of harmful vehicle-related pollutants. Young children are particularly susceptible to air pollution given their narrow airways, higher breathing rates, and developing lungs and immune systems. Few studies, however, have examined air pollution effects among toddlers and preschool-aged children, in part because few registries exist for children 1 to 5 years of age.

Available evidence shows that, among girls aged 4 months to 4 years, exposure to nitrogen dioxide (NO₂) near their home or day care center may be associated with the development of wheezing bronchitis; higher levels of traffic-related air pollutants (NO₂, PM_2.5 [particulate matter 2.5 micrometers or smaller in size], and “soot”) are associated with wheezing, physician-diagnosed asthma, flu, serious colds, and ear, nose, and throat infections; and exposure to air pollution (including NO₂), particularly in combination with exposure to environmental tobacco smoke, increases the risk of recurrent wheezing in children. A study of infants revealed significant associations between traffic-related air pollutants (PM_2.5 and NO₂) and cough without infection and dry cough at night in the first year of life.

Recent studies suggest that vehicle-related pollutants and associated health effects in children are highly concentrated near heavily traveled roadways. Ultrafine particles, black carbon, and carbon monoxide drop to near-background levels at 200 m (650 ft) downwind from major roadways and are indistinguishable from background concentrations at 300 m downwind. An analysis of hospital admissions among children younger than 5 years in Great Britain revealed that children admitted with an asthma diagnosis were significantly more likely than children admitted for nonrespiratory reasons or children from other parts of the community to live less than 500 m from a roadway with high traffic flow (more than 24,000 vehicles per day). Another study showed that children of color residing in California were 3 to 4 times more likely to reside in high-traffic areas than White children, and the potential for exposure to vehicle-related pollution was higher among low-income children.

Previous exposure assessment and time activity studies have demonstrated that significant exposures of infants and children to air pollution can occur at home as a result of indoor pollutants produced by environmental tobacco smoke, cooking, and cleaning; such exposures can also stem from outdoor sources through the intrusion of outdoor air. Outdoor air pollutant concentrations may be heightened in homes in close proximity to major roadways, and children may also experience significant exposures in other microenvironments such as portable classrooms, school buses, and passenger vehicles.

Although children only spend a portion of their day in child care facilities or preschools, the hours spent in these facilities could represent a significant proportion of their overall daily exposure to air pollution, especially if they spend part of the day in moderate or rigorous play outdoors in high-traffic areas. Because many working parents rely on child care, the hours a child spends in a care facility often correspond to the morning or afternoon periods of peak traffic volumes when pollution levels near roadways are most elevated.

Given the potential significance of the child care microenvironment for a child’s overall exposure to air pollution, we assessed the degree to which child care facilities are in close proximity to heavily traveled roadways. To our knowledge, our analyses provide the first estimations of the degree to which young children may be exposed to vehicle-related pollution in this understudied microenvironment, and these estimates have important implications for facility licensing and siting as well as transportation and land-use planning nationwide. Furthermore, an understanding of exposures of children in the child care environment is important for informing and informing the siting of new facilities and may help to improve the location of existing facilities.

Methods. We examined approximately 24,000 licensed child care facilities in California located within 200 m of heavily traveled roadways. Facilities providing care to infants or preschool-aged children and facilities located in disadvantaged areas were more often situated in medium- or high-traffic areas.
microenvironment is especially important
given initiatives in California and other states
to substantially expand existing child care and
preschool systems to ensure that all children
aged 1 to 5 years receive early education be-
fore entering kindergarten.

METHODS

Numerous epidemiological studies have
used traffic densities and distance criteria to
estimate exposures to vehicle-related pollu-
tants. Short of direct experimental measure-
ments of vehicle emissions and individual
exposure, traffic densities and distance pro-
vide a valid proxy for potential exposures to
vehicle-related pollution at a neighborhood,
site, or individual level. We identified maxi-
mum traffic volumes near licensed child care
facilities in California in an attempt to approx-
imate potential magnitudes of exposure to
vehicle-related pollution among young chil-
dren at these facilities.

We used data from the year 2000 on traffic
volumes and child care facilities in California.
We obtained traffic volume data from the
Highway Performance and Monitoring System
maintained by the California Department of
Transportation (CalTrans). These data have
been used and described in previous studies on
the distribution and effects of traffic in
California. Using electronic counting
instruments, CalTrans samples traffic volumes
on major roadways throughout the state at
infrequent intervals and then adjusts these
counts for estimated seasonal traffic fluctua-
tions, weekly variations, and other variables
to estimate annual average daily traffic
(AADT), or an individual roadway segment’s
estimated total volume for the year divided by
365 days. These data contain traffic
counts for freeways, highways, and major ar-
terial roads, but they do not include counts for
local residential streets or distinguish traf-
cic according to vehicle fuel type. Because
residential streets tend to have lower traffic
volumes, we did not expect their exclusion to
significantly affect our results.

We obtained data on facilities licensed to
provide child care in California from the
Community Care Licensing Facility of the
California Department of Social Services. We
included approximately 13 100 child care
centers and approximately 11 000 large fam-
ily care homes in our analyses. Each center’s
capacity was defined as the total number of slots
available for infants (younger than 2 years),
preschoolers (between 2 and 5 years old), or
school-aged children (6 years or older). If a
given facility was licensed to provide care to
children in more than 1 of these age catego-
ries, it was included separately in each cat-
egory in the California data and in our analy-
ses. The large family care homes assessed
here had a capacity of 8 to 14 children.
Information on the remaining family care
homes, which had a capacity of fewer than
8 children and represented approximately
70% of licensed family care homes in the
state, was not available as a result of confi-
dentiality concerns.

Because segment-level CalTrans traffic vol-
ume data are not adequate for geocoding ad-
dress locations, we geocoded child care cen-
ters with Topologically Integrated Geographic
Encoding and Referencing (TIGER; US Cen-
sus Bureau) roadway data with an average
offset from roadway center lines of 13.5 m.
We obtained data on geographic locations of
licensed child care facilities from the Califor-
nia Transportation Needs Assessment proj-
et; approximately 92% of facilities in-
cluded in this database had valid addresses
and were geocoded. Use of a standard offset
may result in misclassifications in cases in
which a facility’s distance from the roadway
center line significantly varies from this dis-
tance. Misclassifications can also result from
other issues relating to the spatial accuracy of
the geocoding process.

We transformed the CalTrans traffic data
and geocoded facility data into a common ge-
ographic projection, Universal Transverse Mer-
cator, so that we could construct geographic
overlays and make consistent distance calcula-
tions. We identified all CalTrans roadway seg-
ments within 200 m of facilities because this
distance corresponds closely with the distance
from major roadways at which vehicle-related
air pollutants drop to near-background concen-
tration levels. In the case of each child
care facility, we identified the segment with
the highest AADT and assigned this maximum
AADT value to the facility as an approxima-
tion of the highest level of traffic volume near
the facility on an average day.

Although the distance and traffic volume
thresholds used in available studies vary, they
suggest that a proximity of 100 m to 500 m
from roadways with a traffic volume of
approximately 24 000 or more vehicles per day
is associated with adverse effects. As
did Green et al., we classified child care
facilities with a maximum nearby AADT of
50 000 or more vehicles per day as being
located in high-traffic areas, facilities with a
maximum nearby AADT between 25 000
and 49 999 as being located in medium-
traffic areas, and facilities with a maximum
nearby AADT below 25 000 AADT as being
located in low-traffic areas. Facilities with no
attributable traffic within 200 m were consid-
ered to be located in very-low-traffic areas.
These classifications may underestimate
traffic volumes for facilities with 2 or more
nearby moderate-traffic roadway segments
that, when combined, produce relatively high
overall volumes.

Previous studies have shown that CalTrans
line segments do not align perfectly with the
TIGER roadway data used to geocode child
care facilities. Such misalignment could re-
sult in misclassifications of nearby traffic vol-
umes. In the current study, the aver-
age discrepancy between 2 street segments in
Los Angeles County was 13.3 m, with a stan-
dard deviation of 19.5 m. Two earlier studies
addressed this discrepancy by transferring
AADT values from CalTrans line segments to
Los Angeles County TIGER-based line seg-
ments and one of these studies suggested that
misclassifications were minimized at dis-
tances above 150 m.

Although a similar reassignment was not
feasible on a statewide scale, we used the
same technique to assess the magnitudes of
potential misclassifications in Los Angeles
County. At a threshold distance of 200 m,
41 more facilities (or 0.2% of all facilities)
were classified in the medium- and high-traffic
categories when uncorrected data were used
than when corrected data were used. Given
that this potential error was small and did not
change the overall percentage of facilities in
these categories, we assumed that positional
errors because of segment misalignment were
randomly distributed in the state and did not
cause differential aggregate-level misclassifica-
tion at a 200 m threshold.
We estimated the number of young children potentially exposed to vehicle-related pollution on the basis of numbers of child care slots in facilities with a medium- or high-traffic roadway within 200 m. We identified traffic levels according to facility capacity category and type of facility: large family care home with a capacity of 8 or more children, infant care center, center providing care for preschool-aged children, or center providing care for school-aged children. We determined the 2000 census block group in which a facility was located by overlaying the facility’s location with TIGER block-group area boundaries, which are smaller than census tracts and often correspond with major roads, bodies of water, or railroads. Census block groups contain an average of about 1500 people; their size can vary depending on land use and population density.

We used census-based area characteristics to derive several block-group classifications that allowed us to assess potential effects on disadvantaged communities. These classifications were as follows: minority area (more than 50% non-White residents), Black area (more than 50% African American or Black residents), Latino area (more than 50% Hispanic residents), poor area (more than 20% of residents living in poverty), foreign-born area (more than 35% of residents born outside the United States), limited English area (more than 15% of residents with limited English proficiency), and limited education area (more than 35% with less than a high-school education).

We also examined the built environments near facilities, including nearby population density, employment density (number of private-sector jobs per square mile in a facility’s tract, derived from the American Business Information database), types of residential parcels, and presence of a highway. We used data from the Statewide Database of the University of California at Berkeley to determine the distribution of residential parcels at the block-group level in 2001, including single-family and multifamily parcels.

In addition to descriptive analyses, we conducted a polytomous logistic regression analysis to model the odds of a facility being located in a medium-traffic area versus a low- or very-low-traffic area and the odds of a facility being located in a high-traffic area versus a low- or very-low-traffic area. We computed odds ratios (ORs) indicating the extent to which facility and area explanatory variables influenced the likelihood of a facility being located in a medium- or high-traffic area.

**RESULTS**

Although the majority (75%) of licensed child care facilities were situated in low- or very-low-traffic areas, slightly more than 1500 of the facilities studied (6%) were situated in high-traffic areas, and these facilities accounted for approximately 57 200 children when they were filled to capacity (Table 1). Almost 4500 facilities (19%), accounting for up to approximately 171 800 children, were located in medium-traffic areas.

Potential exposure of children to traffic-related pollution varied according to facility type (Table 1). Children in infant care facilities were most likely to receive care in high-traffic areas (9%) and medium-traffic areas (29%), followed by children in preschool facilities (8% and 25%, respectively). In addition, children in facilities with higher capacities were more likely to receive care in medium- or high-traffic areas. Conversely, children in facilities with lower capacities, large family care homes, and facilities providing care to school-aged children were less likely to receive care in medium- and high-traffic areas.

Children in minority area facilities were more likely than children in non-minority area facilities to receive care in medium-traffic areas (Table 2). This pattern was more pronounced in minority areas that were predominantly African American. Children in facilities in poor, foreign-born, limited English, and limited education areas were also more likely to receive care in medium-traffic areas. In addition, children in facilities located in foreign-born areas and limited English areas were slightly more likely than those in facilities located in the other block-group categories to receive care in high-traffic areas.

Children in facilities located in high-density residential areas were more likely to receive care in medium- and high-traffic areas (Table 3). Children in facilities located in areas with more than 25% nonresidential parcels were slightly more likely to receive care in medium- or high-traffic areas, whereas children in facilities located in areas with more than 25% multifamily residential parcels had a substantially higher likelihood of receiving care in medium-traffic areas (39%) and a slightly higher likelihood of receiving care in high-traffic areas (10%).

### Table 1—Capacities of Licensed Child Care Centers, by Facility Type and Size: California, 2000

<table>
<thead>
<tr>
<th>Facility capacity, no. of slots</th>
<th>Very-Low-Traffic Area, No. (%)</th>
<th>Low-Traffic Area, No. (%)</th>
<th>Medium-Traffic Area, No. (%)</th>
<th>High-Traffic Area, No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-12</td>
<td>12 020 (23)</td>
<td>29 343 (55)</td>
<td>8 718 (16)</td>
<td>3 083 (6)</td>
</tr>
<tr>
<td>13-20</td>
<td>29 112 (24)</td>
<td>68 967 (56)</td>
<td>18 130 (15)</td>
<td>7 154 (6)</td>
</tr>
<tr>
<td>21-50</td>
<td>28 266 (13)</td>
<td>127 014 (59)</td>
<td>44 401 (21)</td>
<td>13 972 (7)</td>
</tr>
<tr>
<td>&gt;50</td>
<td>56 042 (14)</td>
<td>220 773 (54)</td>
<td>100 569 (25)</td>
<td>32 964 (8)</td>
</tr>
</tbody>
</table>

Note. Percentages in each row sum to 100. See text for descriptions of traffic area categories.
The results of the multinomial logistic regression analysis showed that facility-level factors and area-level factors were associated with the odds of a facility being located in a medium- or very-low-traffic area versus a low- or very-low-traffic area and the odds of a facility being located in a high-traffic area versus a low- or very-low-traffic area. Significance levels should be considered in terms of the large sample size, which enhanced the statistical power of the model. Although this enhanced statistical power could have resulted in some of the correlates being significant even when their differences across groups were relatively small, several of the results obtained are informative.

After control for other factors, facility capacity had a significant but relatively small impact on the odds of a facility being located in a high-traffic area. The odds ratio associated with each 10-slot increase in capacity was 1.03 for both medium- and high-traffic areas (Table 4). Facility type had a large impact on the odds of a facility being located in a medium- or high-traffic area. Family child care homes were less likely than other types of facilities to be located in medium-traffic areas (OR=0.88) and more likely to be located in high-traffic areas (OR=1.13). Infant care centers were much more likely to be located in both medium-traffic (OR=1.40) and high-traffic (OR=1.38) areas. Centers providing care for preschool-aged children were also more likely to be located in medium-traffic (OR=1.13) and high-traffic (OR=1.20) areas.

An increase of 10% in the number of Black residents living in nearby areas was associated with an odds ratio of approximately 1.10 of a child care center being located in a medium- or high-traffic area. Higher percentages of Latino/Hispanic residents living nearby increased the likelihood of a facility being located in a medium- or high-traffic area by a slightly lower magnitude. A 10% increase in the number of foreign-born residents living nearby was associated with approximate odds ratios of 1.20 and 1.30 of facilities being located in medium- and high-traffic areas, respectively.

After control for facility-level and other area-level characteristics, location in a high-density area was a significant predictor of a facility being in a medium-traffic area but was not a significant predictor of a facility being in a high-traffic area. Facilities with high nearby employment densities were more likely to be located in both medium- and high-traffic areas. Higher percentages of nearby multifamily parcels were associated with higher probabilities of child care centers being located in medium-traffic areas.

**DISCUSSION**

This study suggests that approximately 57,000 of the available slots in California child care centers (7% of the overall capacity) are in facilities located within 200 m (650 ft) of roadways averaging 50,000 or more vehicles per day. Atmospheric science and epidemiological studies consistently suggest that such proximity to this level of traffic is associated with high concentrations of vehicle-related pollutants and a variety of adverse health effects, particularly for young children. Furthermore, almost 172,000 of the state’s available child care slots (21% of

**TABLE 2—Capacities of Licensed Child Care Centers, by Area Racial/Ethnic Composition and Socioeconomic Status: California, 2000**

<table>
<thead>
<tr>
<th>Total slots</th>
<th>Very-Low-Traffic Area, No. (%)</th>
<th>Low-Traffic Area, No. (%)</th>
<th>Medium-Traffic Area, No. (%)</th>
<th>High-Traffic Area, No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Race/ethnicity classification</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minority area</td>
<td>125 440 (16)</td>
<td>446 103 (56)</td>
<td>171 818 (21)</td>
<td>57 173 (7)</td>
</tr>
<tr>
<td>Black area</td>
<td>2 307 (9)</td>
<td>12 957 (48)</td>
<td>10 085 (37)</td>
<td>1 703 (6)</td>
</tr>
<tr>
<td>Latino area</td>
<td>16 676 (11)</td>
<td>86 694 (58)</td>
<td>35 635 (24)</td>
<td>9 543 (6)</td>
</tr>
<tr>
<td>Socioeconomic classification</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor area</td>
<td>19 491 (11)</td>
<td>103 061 (57)</td>
<td>46 317 (25)</td>
<td>13 528 (7)</td>
</tr>
<tr>
<td>Foreign-born area</td>
<td>22 518 (11)</td>
<td>100 965 (51)</td>
<td>58 183 (29)</td>
<td>17 574 (9)</td>
</tr>
<tr>
<td>Limited English area</td>
<td>7 821 (10)</td>
<td>43 007 (54)</td>
<td>23 164 (29)</td>
<td>6 188 (8)</td>
</tr>
<tr>
<td>Limited education area</td>
<td>22 042 (12)</td>
<td>105 531 (58)</td>
<td>43 292 (24)</td>
<td>11 616 (6)</td>
</tr>
</tbody>
</table>

Note. Percentages in each row sum to 100. See text for descriptions of traffic area classifications.

**TABLE 3—Capacities of Licensed Child Care Centers, by Nearby Population Density, Highway Proximity, and Type of Nearby Residential Land Use: California, 2000**

<table>
<thead>
<tr>
<th>Total slots</th>
<th>Very-Low-Traffic Area, No. (%)</th>
<th>Low-Traffic Area, No. (%)</th>
<th>Medium-Traffic Area, No. (%)</th>
<th>High-Traffic Area, No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tract population density</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very low (quartile 1)</td>
<td>47 951 (24)</td>
<td>117 602 (60)</td>
<td>19 879 (10)</td>
<td>10 412 (5)</td>
</tr>
<tr>
<td>Low (quartile 2)</td>
<td>36 040 (17)</td>
<td>122 059 (58)</td>
<td>38 637 (18)</td>
<td>15 116 (7)</td>
</tr>
<tr>
<td>High (quartile 3)</td>
<td>26 658 (13)</td>
<td>109 972 (55)</td>
<td>49 138 (24)</td>
<td>14 804 (7)</td>
</tr>
<tr>
<td>Very high (quartile 4)</td>
<td>14 791 (8)</td>
<td>96 470 (50)</td>
<td>64 164 (33)</td>
<td>16 841 (9)</td>
</tr>
<tr>
<td>Highway proximity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highway within 200 m</td>
<td>...</td>
<td>17 679 (20)</td>
<td>24 560 (28)</td>
<td>46 924 (53)</td>
</tr>
<tr>
<td>No highway within 200 m</td>
<td>125 440 (16)</td>
<td>446 103 (56)</td>
<td>171 818 (21)</td>
<td>57 173 (7)</td>
</tr>
<tr>
<td>Parcel distribution</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 25% nonresidential</td>
<td>41 587 (15)</td>
<td>147 218 (53)</td>
<td>68 155 (24)</td>
<td>22 237 (8)</td>
</tr>
<tr>
<td>&gt; 75% single-family residences</td>
<td>76 450 (18)</td>
<td>245 365 (58)</td>
<td>75 383 (18)</td>
<td>26 842 (6)</td>
</tr>
<tr>
<td>&gt; 25% multifamily residences</td>
<td>2 452 (4)</td>
<td>33 156 (47)</td>
<td>27 453 (39)</td>
<td>6 818 (10)</td>
</tr>
</tbody>
</table>

Note. Percentages in each row sum to 100. See text for descriptions of traffic area categories.
TABLE 4—Odds of Child Care Facilities Being Located Within High- or Medium-Traffic Areas vs Low- or Very-Low-Traffic Areas: Multinomial Logistic Regression Results for California, 2000

<table>
<thead>
<tr>
<th>Area Built Environment Variables</th>
<th>Medium-Traffic Area (Coefficient OR 95% CI)</th>
<th>High-Traffic Area (Coefficient OR 95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural log of population density</td>
<td>0.276*** 1.32 (1.25, 1.39)</td>
<td>-0.006 0.99 (0.92, 1.07)</td>
</tr>
<tr>
<td>Natural log of employment density</td>
<td>0.257*** 1.29 (1.25, 1.34)</td>
<td>0.350*** 1.42 (1.34, 1.50)</td>
</tr>
<tr>
<td>Percentage of single-family parcels</td>
<td>-0.003* 1.00 (1.00, 1.00)</td>
<td>-0.003 1.00 (0.99, 1.00)</td>
</tr>
<tr>
<td>Percentage of multifamily parcels</td>
<td>0.011*** 1.01 (1.01, 1.01)</td>
<td>0.005 1.00 (1.00, 1.01)</td>
</tr>
</tbody>
</table>

Note: OR = odds ratio; CI = confidence interval. Odds ratios were calculated as the exponents of regression coefficients. See text for descriptions of traffic area categories.

*P<.01; **P<.001; ***P<.0001.

Because significantly fewer child care and early education facilities are located in these areas than in more affluent areas, the First 5 program, whose goal is to provide preschool access to every 4-year-old child in Los Angeles, has targeted the expansion, renovation, and rehabilitation of existing facilities in underserved areas so that all communities can benefit. Programs should carefully consider near-roadway air pollution concerns in evaluations of facility location and expansion criteria to ensure that preschool children residing in the most disadvantaged neighborhoods are not systematically subjected to higher concentrations of vehicle-related pollutants.

Further research is needed to better understand the extent to which our findings can be generalized to other states, especially given that land use patterns, spatial inequalities, and child care siting constraints and licensing procedures vary by region. Given the pervasiveness and economic importance of roadways, however, multiple strategies will probably be necessary to address the adverse effects of vehicle-related pollution on young children on a nationwide scale. Such efforts should adopt a framework that draws from both public health and urban planning to broadly understand the health implications of the transportation infrastructure.

Strategies in California could inform responses in other states. Evidence of the high concentration of harmful air pollutants near roadways prompted the California legislature to prohibit public schools within 150 m (500 ft) of busy corridors to protect children’s health. Further pollution and exposure monitoring at child care facilities could reveal whether this legislation should be expanded to prohibit the siting of child care facilities within 200 m of major roadways, which more closely corresponds to the distance from major roadways at which vehicle-related air pollutants drop to “background” concentration levels. The California Air Resources Board recently responded to growing concern...
over near-roadway pollution by recommending that new “sensitive land uses” such as residences, schools, day care centers, playgrounds, and medical facilities not be sited within 150 m of heavily traveled roadways.65 Even if such recommendations are fully implemented, it is highly unlikely that large-scale facility restiting will take place in the immediate future given current market and siting constraints. Additional mitigation approaches may include installing and properly using air filtration systems to limit the intrusion of outdoor air, locating playgrounds and other sites of outdoor activities as far as possible near roadways, and restricting rigorous outdoor activities during high traffic periods.

Child care and preschool facilities near major roadways should be required to notify parents and guardians of the potential health risks of concentrated vehicle-related pollutants or other nearby air pollutants before children are enrolled. This could alert parents of vulnerable children, such as those with chronic respiratory conditions, of potential risks.

Human Participant Protection

No protocol approval was needed for this study.

References

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Contributors

D. Houston was primarily responsible for the research and writing of the article. All of the authors contributed to the foundation and conceptualization of the study, to interpretation of findings, and to revisions of the article.

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