Reducing Pedestrian's Exposure to Traffic-Related Air Pollution through Route Choice Decision

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Outline

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• Sidewalk characterization and routing
• Routing results
• Discussion
Introduction

Neighborhoods in the City of Riverside, California
Point A: weather station, Point B: air quality measurement station

- Riverside City Walkability Improvement Project
- Model mobile-source fine particle concentration within the neighborhoods
- Promote walking and reduce pedestrians’ exposure to mobile-source pollutant
Roadside measurements reveal that concentration of traffic emissions are elevated near roadways (Zhu et al., 2006; Hu et al. 2009, 2012).

Pedestrians and cyclists face risks of higher exposure to traffic emissions. Exposure duration, breathing rate are both high. (O’Donoghue et al., 2007; Briggs et al. 2008; Morabia et al. 2009)

An illustration of concentration upwind and downwind a roadway

Neighborhoods in the City of Riverside, California
Objective

Apply a modeling method to calculate averaged mobile-source PM2.5 concentration distribution for morning and afternoon periods.

Using the PM2.5 map, can route choice decisions help reduce pedestrian’s exposure to traffic-related air pollution?

Three walking route options for a home-to-school trip in Riverside
Method of PM2.5 modeling

Traffic Mode

Traffic Network → Traffic Activity

Emission Mode

Traffic Activity → Traffic Emissions

Dispersion Mode

Traffic Emissions → Air Pollutant Concentration

Riverside County Transportation Analysis Model

EMFAC2011

CALINE4
Map of traffic activity

Total flow (vehicles per hour) for morning periods.
Map of PM2.5 concentration

Mobile-source PM2.5 concentration in the morning
Map of PM2.5 concentration

Mobile-source PM2.5 concentration in the afternoon
Sidewalk characterization

Contrast between roadway map (a) and sidewalk map (b) for pedestrian routing
Sidewalk characterization

a section of paved sidewalk (blue line)  
a section of landscape/lawn sidewalk (green line)  
a crosswalk (coral line)

Digital sidewalk categories defined by the author
Sidewalk characterization

- a section of driveway/parking-lot (purple line)
- a missing sidewalk (red line)
Sidewalk characterization

More than 166 miles of sidewalk, 70% are paved sidewalk

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Routing experiments

1.2 meter/second walking speed, 30-minute one trip

Location of homes and amenities used in route choice evaluation
An example trip

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Morning</th>
<th>Afternoon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking time increase</td>
<td>1%</td>
<td>0.3%</td>
</tr>
<tr>
<td>PM2.5 Inhale Mass decrease</td>
<td>72%</td>
<td>92%</td>
</tr>
</tbody>
</table>
Statistics of routing results

<table>
<thead>
<tr>
<th>Analysis Period</th>
<th>Trips under 30 minutes</th>
<th>Improved Trips</th>
<th>PM$_{2.5}$ Exposure Reduction (%)</th>
<th>Walking Duration Increase (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trips</td>
<td>%</td>
<td>Max</td>
<td>Median</td>
</tr>
<tr>
<td>Morning</td>
<td>7223</td>
<td>367</td>
<td>5.1</td>
<td>84.4</td>
</tr>
<tr>
<td>Afternoon</td>
<td>7223</td>
<td>697</td>
<td>9.6</td>
<td>98.2</td>
</tr>
</tbody>
</table>

Reduction in PM$_{2.5}$ exposure versus increase in walking duration for improved trips
Conclusions and discussion

A low exposure route could be found for 5.1% of the walking trips in the morning, and 9.6% of the trips in the afternoon.

On average, the low exposure routes would reduce the pedestrian exposure to PM$_{2.5}$ during the morning period by 24% while increasing the walking duration by only 1%.

During the afternoon period, the low exposure routes would reduce the pedestrian exposure to PM$_{2.5}$ by an average of 32.0% while increasing the walking duration by 1.1% on average.

Digital sidewalk network improves the reliability of pedestrian routing.
Future improvements

Collect real-time meteorology and traffic activities, develop the real-time mobile-source pollutant modeling system.

Validate modeling results with instrumental measurements.

Automate sidewalk digitization process.

Apply the digital sidewalk system to support safe routes calculation for active travelers. For example, a route with more paved sidewalk sections.
Acknowledgments

California Department of Transportation

County of Riverside

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