Children in Risk: Potential Highway-Related Health Risks and Its Socioeconomic and Ethnic Disparities in Los Angeles County

- Introduction

Busy highways incur high health risk because of the emitted or generated air pollutants like particular matters, NOx, SO2, and ozone. Not only they may worsen diseases, but some evidence warns that years of breathing the pollution near busy roads may increase the risk of developing chronic diseases (American Lung Association (ALA), 2012). Among those at higher risks to such pollution, children are more susceptible due to the potential damage to their developing respiratory organizations as well as their spending more time playing outside. Growing academic evidence has linked the exposure to air pollution of heavy traffic with children’s respiratory diseases like asthma and chronic bronchitis (ALA, 2012; Gauderman, 2007; Kim. et al., 2004; Joel Schwartz, 2004). In January 2010, the Health Effect Institute published a major review of the evidence, concluding that traffic pollution causes asthma attacks and other diseases like lung or cardiovascular diseases in children over 700 studies from around the world. They also concluded the most affected area near highway is roughly 0.2 miles from highway (ALA, 2012).

Los Angeles metropolitan area has “championed” the most polluted area for around 10 years from 2000 to 2010 based on the report released by the American Lung Association; Also, Los Angeles is famous for its busy and congested highway network. Based on the AADT (Annual Average Daily Traffic) report, the average AADT of Los Angeles is in the top three of California State, and it has several busiest highways running through its area, like I-10, I-405 and US 101. Parallel with its heavy traffic, Los Angeles has outstanding number of people suffering lung diseases (ALA, 2012): in 2012, there’re 159,352 children suffering asthma.

In this study, I want to use GIS to map and explore how many children (under 18) live near the three busiest highways in Los Angeles County (I-10, I-405 and US 101) and are exposed to high health risks, as a pilot research. In addition, many previous studies show significant socioeconomic and ethnic disparities among children exposed to traffic-related health issues (Gunier, 2003; Houston, 2004; Morello-Frosch et al., 2002), arguing that people of low income and minority (especially African Americans) may have more potentials to live near highways and thus have high probabilities to have lung diseases. Thus, in this paper, I would examine whether there’s such disparities existing in the three major highways using median household income and black population ratio.

- Data and Methodology

Traffic data and influenced block groups selection

The existing air monitoring stations are too geographically sparse to characterize the differences in ambient pollutant concentrations for small areas like a census block groups. For a specific residence or point, models have been developed to estimate pollutant concentrations as a function of traffic volume and distance from the road (Kono and Ito, 1990; Versluis, 1994). In this study, Annual Average Daily Traffic (AADT) data of the selected highways is used to represent hazardous air pollutants that the children are potentially exposed to; literatures have diverse critical distance standards from a busy road or highway ranging from 300 feet to 1600 feet depending on different geographical factors (Brugge, 2007; Zhu, Y, et al., 2002). As an exploratory research, a more conservative distance is chosen as 600 feet to represent the potentially most seriously air-pollution influenced block groups. AADT data for 2010 is provided by the Highway Performance and Monitoring System.

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2 Source: [http://traffic-counts.dot.ca.gov/](http://traffic-counts.dot.ca.gov/)
3 Source: [http://www.cdc.gov/nchs/data/databriefs/db94.htm#prevalence](http://www.cdc.gov/nchs/data/databriefs/db94.htm#prevalence)
4 2010 AADT data is used due to the 2010 census data is used for socioeconomic and ethnic analysis
GIS Project by Qian Xu

maintained by the California Department of Transportation (California Department of Transportation, 2010). The AADT represents the average number of vehicles per day traveling in both directions on a road segment. In the study, the Ahead-AADT (north or east direction) data has been used for GIS spatial referencing purpose. The road segments are spatially referenced in a GIS database by the monitor sites’ milepost location (north or east direction). Each block group is assigned the AADT data of the closest monitor station in the certain highway road segment by GIS Join Function.

**Demographic and Socioeconomic data**

To investigate the children population distribution in the area near selected highways, the population data (people under 18) is achieved on block group level from census bureau’s website. The 2010 census SF1 data is used. The children population by different races (population under 18) on block group level has been achieved for the ethnic disparity study. Also, the 2010 Median Household Income data on block groups is used for socioeconomic disparity analysis.

To standardize the data for the three highways and make comparison among them, the black population ratio (black population/total population) would be used for the race disparity analysis; the ratio of the median household income of every block group divided by California average median household income would be used for the income disparity analysis.

**Children-related sites data**

To investigate distribution of sites where children spend most of time (child care, schools) in heavy traffic area (AADT>200,000), the points of interest data has been achieved from the Los Angeles County GIS Data Port. Organizations like early childhood education and head start, public elementary, middle and high school, private and charter schools, child care facility, children and family services sites are selected using selection by attributes and join function in GIS.

**GIS and data analysis**

**Layer Creation**

The following figures show the GIS process for the analysis. ① Firstly, the three highways I405, I 10 and US101 have been selected and exported as single layer. ② Then as what have been introduced above, the block groups studied near the highways are selected by a 600 feet distance using selection by location function in GIS. ③ The block groups will be assigned related AADT information provided by the highway monitor stations, using the spatial joining with closest distance function. Then every block group will be assigned respective AADT information (Figure 1).

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5 GIS spatial referencing of the road segments of highways is based on the monitor stations’ postmiles for certain direction. In this study, the north or east direction postmiles have been selected, thus the respective ahead AADT data is used instead of back AADT data (west or south direction).

6 Only the one race has been used, children who are two or more races are not in the data sets.

7 The black population ratio is chosen as the representative for race disparity, because black persons generally have higher asthma rate.

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![Figure 1 GIS Process Mode for AADT](image1.png)

![Figure 2 GIS Process Model for Children Population](image2.png)
Similarly, the selected block groups will be joined with the children demographic information of population and race information as well as median household income information (model as Figure 2). The major differences of joining process of the latter three layers are that, selected block groups will be assigned respective children population, median household income and race data by joining with specific table function using block group ID, instead of by spatial joining.

**Graduated-Color Layer generation and Comparisons**

Then these four layers of each highway will be drawn in graduated color to show the frequency distribution for AADT, children population, race and income level. The latter three maps will be compared with the AADT map. The same standards for graduated colors will be used for comparison between highways. The ranges of classes for the four data sets are as below.

<table>
<thead>
<tr>
<th>Data Set</th>
<th>Class 1</th>
<th>Class 2</th>
<th>Class 3</th>
<th>Class 4</th>
<th>Class 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>AADT</td>
<td>&lt;120,000</td>
<td>120,000 – 150,000</td>
<td>150,000 – 200,000</td>
<td>200,000 – 250,000</td>
<td>&gt;250,000</td>
</tr>
<tr>
<td>Children Population</td>
<td>&lt;150</td>
<td>150 – 300</td>
<td>300 – 450</td>
<td>450 – 600</td>
<td>&gt;600</td>
</tr>
<tr>
<td>Black Ratio</td>
<td>&lt;0.010929</td>
<td>0.010929 – 0.0329</td>
<td>0.0329 – 0.08492</td>
<td>0.08492 – 0.09677</td>
<td>&gt;0.09677</td>
</tr>
<tr>
<td>Median Household Income Ratio</td>
<td>&lt;0.3</td>
<td>0.3 – 0.5</td>
<td>0.5 – 1.0</td>
<td>1.0 – 2.0</td>
<td>&gt;2.0</td>
</tr>
</tbody>
</table>

**Data and Statistical Analysis**

1. The children population living in the block groups near each highway will be calculated using summarization function in GIS;
2. The frequency distribution map of AADT will be compared with the distribution maps of children population near highways, median household income and black race ratio separately, in order to gain a fundamental sense of traffic-related air pollutants risk to children population and its related income and race disparities.
3. More specific frequency tables and histograms will be generated to have a more detailed view of the income and race disparities based on the data set using selection by query function;
4. Frequency tables of different children-related sites (like schools, child care center) near each highway (within 600-feet block groups) will be generated to see how many children-active places in Los Angeles County in areas near the three busiest highways.

**Results/conclusion**

**Traffic Density of the Three Highways**

The selected three high ways in Los Angeles County – I405, I10, and US101, are among the busiest highway in 2008. The average Ahead-Annual Average Daily Traffic (North or East Direction) across Los Angeles County of their selected road segments are 212,277 for I10, 216,922 for US101 and 260,500 for I405, all above 200,000. The AADT frequency histograms for road segments of each highway are shown as below. We can see that compared to US 101, the AADT distributions for I405 and I10 are more skewed to right (above 200,000), implying their heavy traffic.

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8 120,000 is chosen because it is the smallest AADT among the three highway; 250,000 is chosen for that US Department of Transportation uses it defining “most travelled urban highway”;
9 The values of the classes are chosen based on the quartile divisions of the black ratio in Los Angeles County using 2010 census data (note, 0.0329 is the median value of black ratio in block groups in Los Angeles County);
10 In 2010, CA average of median household income is $60,883;
11 Data Source: [http://www.fhwa.dot.gov/policyinformation/tables/02.cfm](http://www.fhwa.dot.gov/policyinformation/tables/02.cfm)
12 Middle value of the X-axis range is about 200,000.
Total Children Population near Each Highway

Using the “summarize” tool in GIS, a report including information of total children population by race and by AADT is created for I405, I10 and US 101\textsuperscript{13}. The tables below show the detailed population information.

As we can see, different highways have different percentage of children living in areas close to heavy traffic highway sections (AADT>200,000). For these three highways alone, there are around 154,014\textsuperscript{14} children (around 6.4%\textsuperscript{15} of total Los Angeles County Children Population) living in heavy-traffic area where the health threat is very high, especially for I405 which has highest average AADT and highest children population percentage living in heavy traffic area.

For the children of different races, although the ratio distribution will diverse in along different highways, the ratio of black children is always above the average percentage of children living in heavy traffic area.

<table>
<thead>
<tr>
<th></th>
<th>I405</th>
<th>I10</th>
<th>US101</th>
</tr>
</thead>
<tbody>
<tr>
<td>AADT</td>
<td>Sum white latino Black American Indian Asian Native Hawii</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;200,000</td>
<td>54209 12151 27864 5049 1046 6159 430</td>
<td>65004 13645 28896 5799 1192 6630 440</td>
<td>20000 4000 5000 1000 200 1000 50</td>
</tr>
<tr>
<td>Total</td>
<td>57430 12537 30103 5185 1124 6530 434</td>
<td>68508 14045 29896 5999 1192 6630 440</td>
<td>20000 4000 5000 1000 200 1000 50</td>
</tr>
<tr>
<td>Percentage</td>
<td>94.39% 96.92% 92.56% 97.38% 93.06% 94.32% 99.08%</td>
<td>99.67% 99.53% 97.89% 97.16% 96.54% 96.32% 99.63%</td>
<td>100% 100% 100% 100% 100% 100% 100%</td>
</tr>
</tbody>
</table>

\textsuperscript{13} The total population may not equal to the sum of the different races due the omitted some other races or multiple races as well as the reason that they come from different files on 2010 census data (population comes from the sex by age 2010 P12 document, while the race data come from the race 2010 document DP11).

\textsuperscript{14} Calculated by sum of all three children population living in AADT>200,000 area;

\textsuperscript{15} The Total Population under 18 in Los Angeles County based on 2010 Census data (P12) is 2,402,208.
Children Population Distribution, Income and Race Disparity Analysis

Appendix 1, 2, 3 maps respectively show the distribution comparisons between traffic AADT and income level, children population and black people ratio for I405, I10 and US 101. General conclusions are as below:

A. For I10, we can see (1) Children population generally are distributed in area where AADT is higher, although the for some areas where AADT is highest, there’s fewer children population; (2) Middle Mean household income block groups pervade the whole areas along the I10; although no clear evidence shows that the income will be necessarily lower in heavy traffic areas, we can see that the lowest (darkest, ratio is reversely correlated with color) income block groups are within the heavier traffic areas; (3) Block groups where black ratio is higher than L.A. County average (0.03) are distributed generally in heavier traffic areas while in areas where traffic is busier, the ratio is not always higher.

From the block groups frequency distribution for I10 below, we can see more details: (1) Generally all income groups are distributed in high traffic areas including poor block groups; in high traffic area, it is the median block groups dominate the area. (2) Generally, higher black people ratio (>0.3) block groups are distributed more in heavier-traffic areas than areas where AADT<200,000.

<table>
<thead>
<tr>
<th></th>
<th>AADT</th>
<th>Sum</th>
<th>white</th>
<th>latino</th>
<th>Black</th>
<th>American Indian</th>
<th>Asian</th>
<th>Native Hawii</th>
</tr>
</thead>
<tbody>
<tr>
<td>I10</td>
<td>&gt;200,000</td>
<td>66269</td>
<td>3593</td>
<td>49051</td>
<td>4728</td>
<td>2116</td>
<td>8065</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>75365</td>
<td>5071</td>
<td>54675</td>
<td>5154</td>
<td>2374</td>
<td>9417</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td>Percentage</td>
<td>87.93%</td>
<td>70.85%</td>
<td>89.71%</td>
<td>91.73%</td>
<td>89.13%</td>
<td>85.64%</td>
<td>88.30%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>AADT</th>
<th>Sum</th>
<th>white</th>
<th>latino</th>
<th>Black</th>
<th>American Indian</th>
<th>Asian</th>
<th>Native Hawii</th>
</tr>
</thead>
<tbody>
<tr>
<td>US101</td>
<td>&gt;200,000</td>
<td>33536</td>
<td>12648</td>
<td>14286</td>
<td>1517</td>
<td>829</td>
<td>3489</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>50106</td>
<td>20343</td>
<td>21122</td>
<td>1934</td>
<td>1165</td>
<td>4433</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>Percentage</td>
<td>66.93%</td>
<td>62.17%</td>
<td>67.64%</td>
<td>78.44%</td>
<td>71.16%</td>
<td>78.71%</td>
<td>85.45%</td>
</tr>
</tbody>
</table>

B. For I405, we can see (1) Children population generally are distributed in area where AADT is higher, although in where the AADT value is biggest, there may be fewer children; (2) Most areas are high traffic areas, no specific distribution of income groups are clearly found; (3) No specific distribution of black ratio groups are clearly found. From the block groups frequency distribution for I405 below, we can see more details; (1) For I405, most block groups are middle income groups, and no unique distribution characteristic for low income groups are found; (2) Generally, higher black people ratio (>0.3) block groups are distributed more in heavier-traffic areas than areas where AADT<200,000, although most low black ratio groups are distributed in higher areas too.
C. For US101, we can see (1) Children population generally are distributed in area where AADT is lower than 250,000; (2) Middle or high Mean household income block groups pervade the whole areas along the US101, but those groups with low income appear in heavier traffic groups; (3) Block groups where black ratio is higher than L.A. County average (0.03) are distributed generally in heavier traffic areas, and while in areas where traffic is busier, the ratio will be mostly higher too. From the block groups frequency distribution for I10 below, we can see more details: (1) generally, high income groups will live in areas where traffic is less. (2) It is very clear that groups with fewer black people live more evenly along the highway, while higher black people ratio (>0.3) block groups cluster in heavier-traffic areas.

![I405 Income Ratio Frequency Distribution](image1)

![I405 Black Ratio Frequency Distribution](image2)

![US101 Income Ratio Frequency Distribution](image3)

![US101 Black Ratio Frequency Distribution](image4)

**Children-related Sites Analysis**

As figure in Appendix 4 shown, I’ve used the ArcGIS to intersect children-activity related facility sites with the AADT map for I405, and I found there are around or more than 100 sites for all three highways. The number and the type of sites are shown below. As we can see, some of the sites are quite close to the highway, which could be a really potentially big threat to children’s health, especially for those under 10 whose lungs are during active development.

<table>
<thead>
<tr>
<th>Type of Sites</th>
<th>I405</th>
<th>I10</th>
<th>US101</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Childhood Education and Head Start</td>
<td>10</td>
<td>32</td>
<td>17</td>
</tr>
<tr>
<td>Public Elementary School</td>
<td>29</td>
<td>34</td>
<td>16</td>
</tr>
<tr>
<td>Public High School</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Public Middle School</td>
<td>6</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Private or Charters School</td>
<td>45</td>
<td>37</td>
<td>27</td>
</tr>
<tr>
<td>Child Care</td>
<td>7</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>Children and Family Services</td>
<td>29</td>
<td>38</td>
<td>18</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>131</strong></td>
<td><strong>162</strong></td>
<td><strong>88</strong></td>
</tr>
</tbody>
</table>
• **Discussion**

**General Conclusions**

A. Children and children active sites near highway

1) Around 6.4% of total children (under 18) in Los Angeles County live near the selected three highways – I405, I10 and US101. Although the population are not all distributed in the busiest sections of highway, the children’s potential exposure to traffic related air pollutants still deserve more attention. The total influences of highway-related air pollutants to children should be analyzed after the all 32 major highways in Los Angeles County being studied, and results should be compared to other states. 2) There are 381 children-related sites within the block groups near highways (nearly 600 feet). These sites include schools and child care centers where children may spend lots of time. Thus, certain measures should be taken in these schools or centers to reduce the potential harm of highway related health issues like asthma on children.

B. Income and race disparities

Income and race disparities along the three highways are not exactly as expected as the literatures revealed: Poorer people and minorities would have higher potential to live near highways. In the studied three highways, disparities differ among them. For the income disparity of the three highways, the majority of blocks are middle income block groups; although for highway like I405 no specific evidence found that heavier traffic areas will necessarily relates to lower income groups, those lower income groups may have higher possibility to live near busier highway. For the race disparity of the three highways, a general common characteristic is black people would have higher potential to live in heavier traffic area, although there are many blocks near heavier traffic area where the black ratio is very low. More statistical models should be used to analyze the disparities for more accuracy.

**Data Limitation**

A. This study use highway Ahead-AADT traffic data to represent the potential exposure to highway-related pollution, because the direct air pollutants concentration for every block group is not available. There are several problems with this substitution: 1). For AADT of every block group, I use the AADT data from the monitor station nearest to the certain block group, which may not be precise for the whole block area, especially when the group area is large (people live in such area may actually live far away from highway); 2) Just ahead-AADT data is used (north or east direction); although the ahead and back AADT data doesn’t differ a lot, a more accurate model should be used to precisely represent the air pollutants exposure; 3) Omitted influence from other major roads due to the unavailability of AADT data for major local roads.

B. This study focus just on the three busiest highways and this is not enough to get a general and detailed sense of income disparity and race disparity of highway-related air pollution exposure in the whole L.A. County. Further researches about the rest of the highways should be done to have a comprehensive understanding of the potential health threats of highways.

C. Regression models or statistical models should be developed and used to analyze the race, income difference among AADT, instead of just reading from the maps. This would help to conduct a more rigorous analysis of the disparities in L.A. County.
References


Morello-Frosch, R., Pastor Jr, M., Porras, C., & Sadd, J. (2002). Environmental justice and regional inequality in southern California: implications for future research. Environmental Health Perspectives, 110(Suppl 2), 149.


Appendix 2

Comparison of Traffic Density, Income Level, Children Population and Black Ratio of I-10
Appendix 4

Youth Facilities near Highway I-405

Traffic Density of I-405
- 0 - 120000
- 120001 - 150000
- 150001 - 200000
- 200001 - 250000
- 250001 - 325000

Youth Facilities near I-405
- Child Care
- Children and Family Services
- Early Childhood Education and Head Start
- Private and Charter Schools
- Public Elementary Schools
- Public High Schools
- Public Middle Schools