An Examination of Air Pollution and Rates of Pulmonary and Cardiovascular Events for Traffic Dense Areas: A Spatial Analysis of the California Bay Area for 2012

Background

As California's Bay Area population continues to grow from the technological boom, air quality is at risk due to the increase in traffic density. In order to combat poor air quality, the Bay Area Air Quality Management District issues Spare the Air Day alerts on days forecasted to have particularly unhealthy air quality measures for ozone or particulate matter. These alerts are meant to: warn residents who are sensitive to poor air quality to remain indoors, restrict wood burning practices, and encourage Bay Area residents to drive less. From 2010 to 2015 there were a total of 140 Spare the Air Days in the Bay Area, this is up from 91 in the five years prior (2005-2010).[1] This change speaks to the worsening air quality in the area.

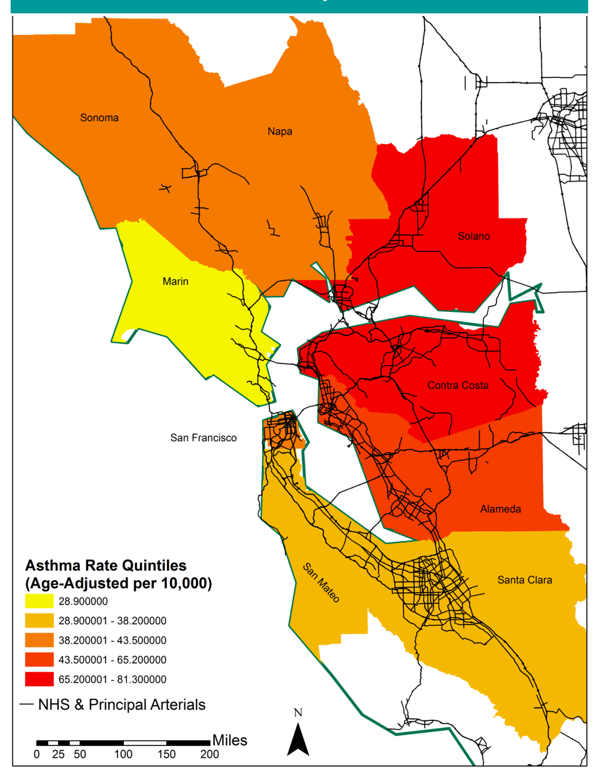
There are several health concerns related to poor air quality, most notably, asthma attacks and acute cardiovascular events.[2,5,7] Through spatial analysis researchers have found a connection between asthma rates, especially in children, and the distance of housing from highways.[3,5] Furthermore, populations of lower socioeconomic status are found to be at an increased risk of exposure to poor air quality.[4,5,6]

This analysis seeks to descriptively map two specific relationships:

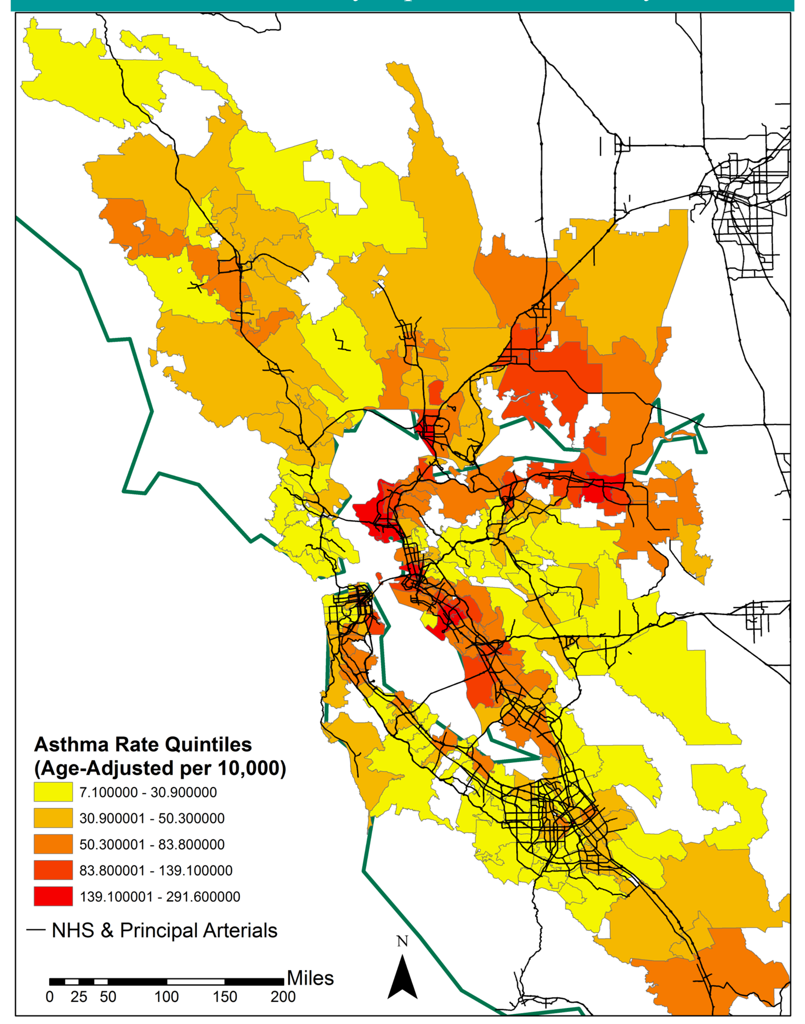
1. Is there an association between traffic density and cardiovascular events in the Bay Area?
2. Is there an association between traffic density and risk of asthmatic events in the Bay Area?

Due to the rapid changes to the urban landscape of the Greater Bay Area it is important to identify the geographic areas at high risk for these public health concerns early, before they become even worse .

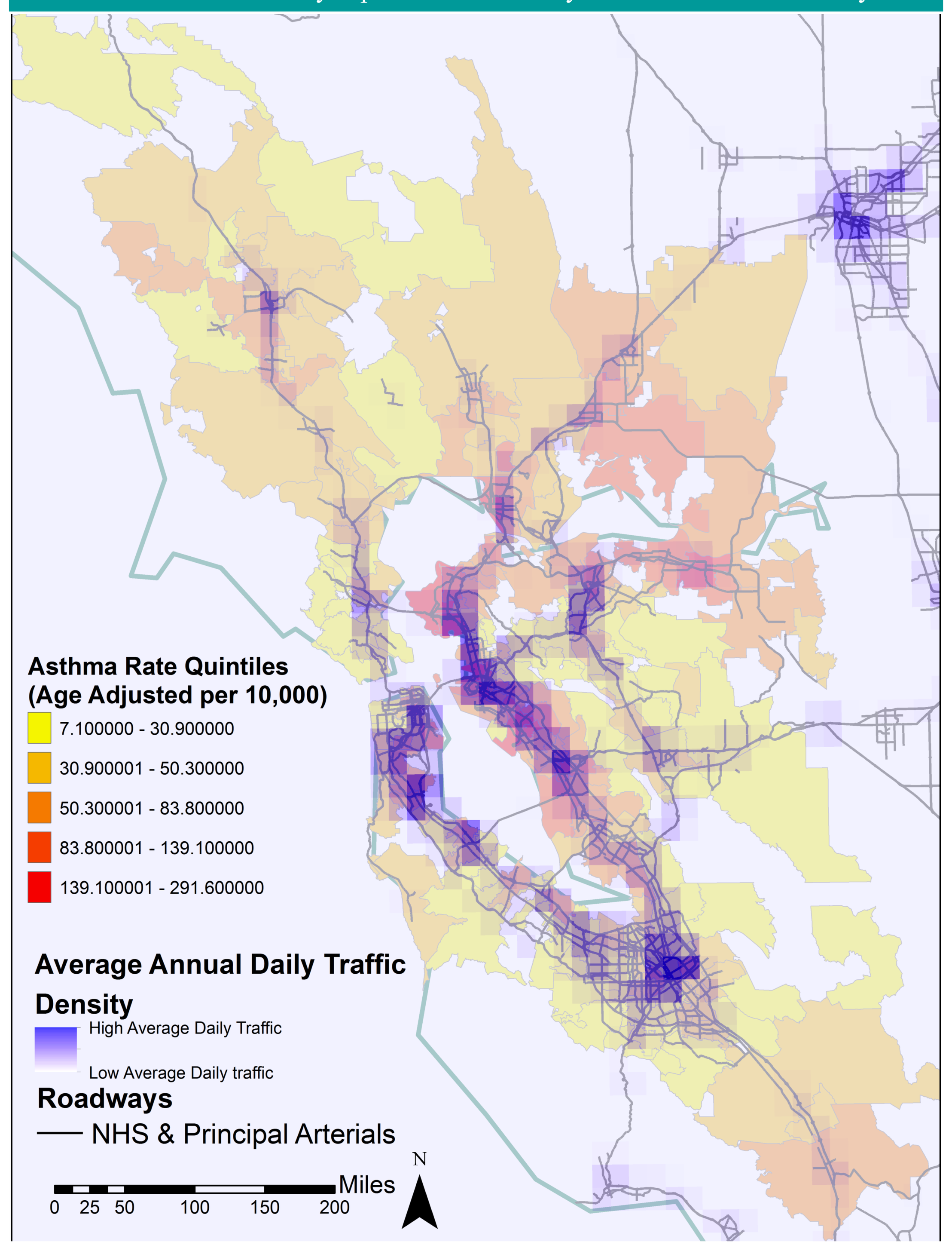
2012 Asthma Rates by County for the Bay Area



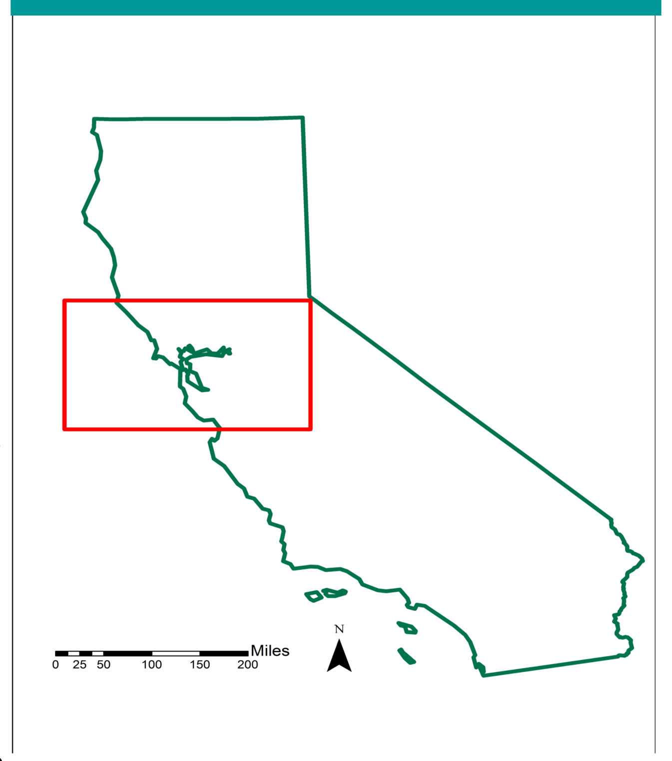
2012 Asthma Rates by Zip Code for the Bay Area



2012 Asthma Rates by Zip Code for the Bay Area with Traffic Overlay



Reference Map - California Bay Area

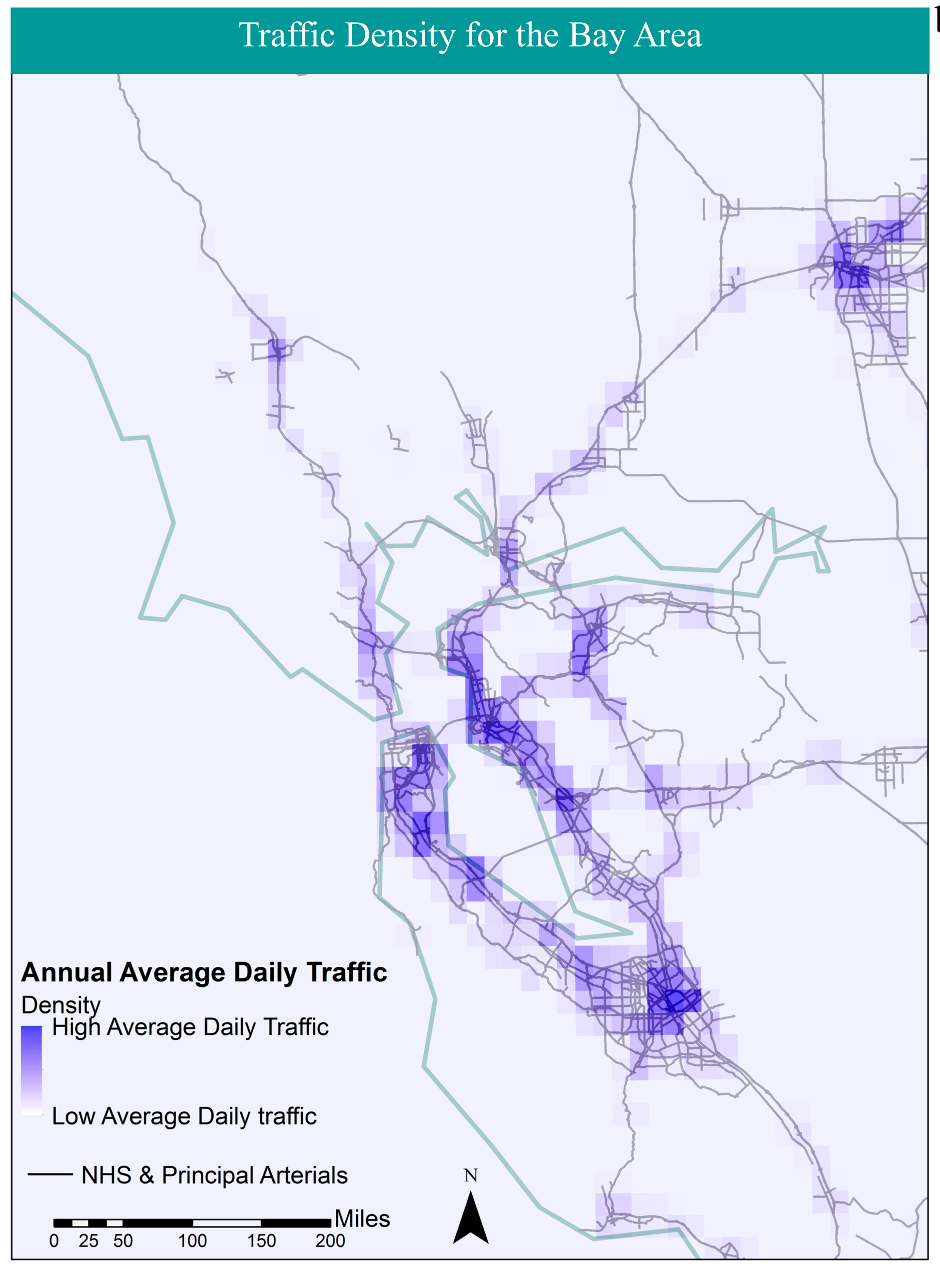


Methodology

Data for this analysis was obtained from a variety of publicly available sources. Health outcome data for 2012 came from the California Department of Public Health. Traffic data and National Highway system shapefiles were obtained for 2012 from the California Department of Transportation. TIGER shapefiles were used to join these datasets to county and zip code level polygons for spatial analysis and display within a geographic information system (ArcGIS version 10.3, Esri Redlands, California).

In order to create a traffic density map, a new variable called Average Annual Daily Traffic (AADT) was created by calculating the average between the Ahead AADT and Back AADT variables (used quantify the one-way traffic counts for a road segment). AADT therefore represents the overall average annual daily traffic count for each road segment. From this variable the point density tool in ArcGIS was used to rasterize the data. The result is the traffic density map displayed here which shows the high and low densities of average annual daily traffic across the Bay Area.

Traffic Density for the Bay Area



For health outcome mapping. Bay Area Myocardial infarction (MI) and Asthma excel data tables were cleaned and joined to TIGER county shapefiles. Using a choropleth map, counties were coded by quintiles based on their rates of either MI or asthma. Counties were labeled for the ease of the viewer using the labeling tool in ArcGIS. The major roadways layer was overlaid on top.

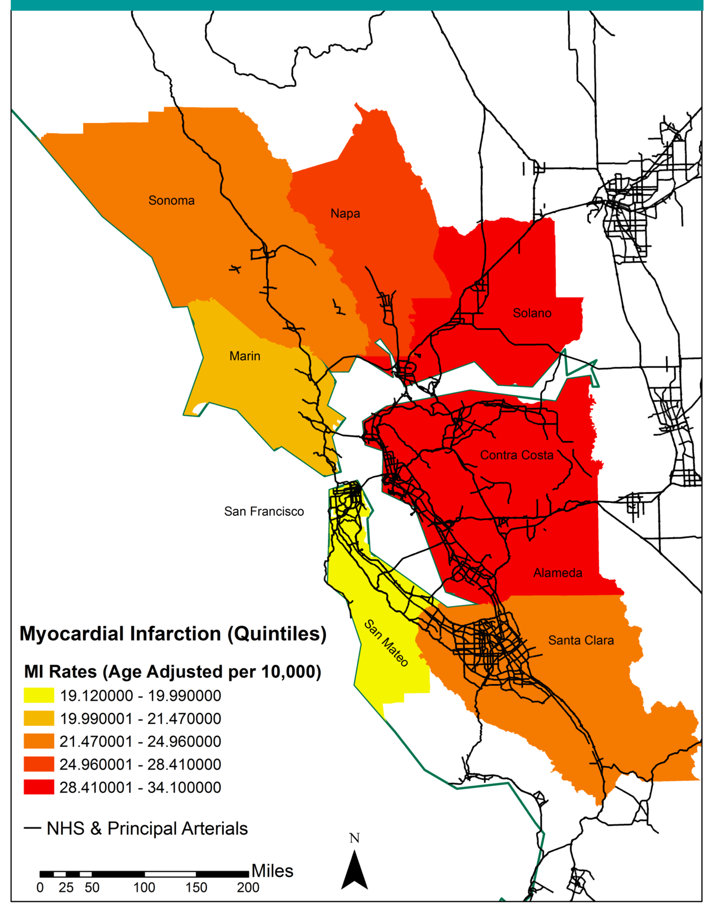
Asthma rates were spatially analyzed further at the zip code level using a choropleth map; zip codes were coded by quintiles based on rates of asthma.

Both MI rates per county and Asthma rates per zip code were overlaid with the traffic density layer in order to assess the spatial relationship between areas of high traffic density and rates of MI and asthma.

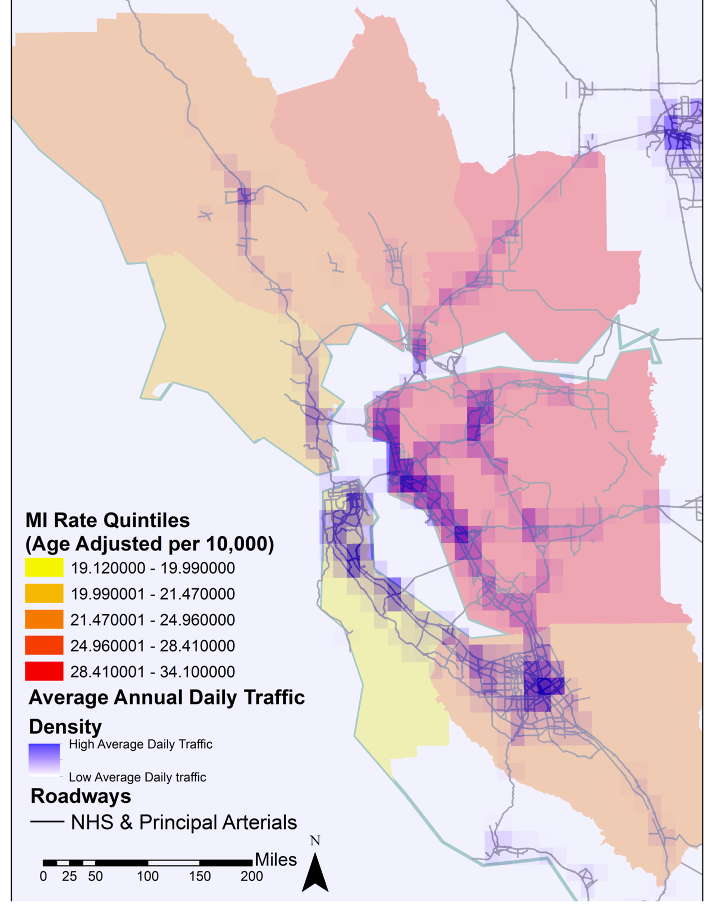
Results

Looking at the traffic density map, it is seen that the densest areas of average annual daily traffic spatially correlates well with areas of the Bay Area that have the most highways. Based on past research showing that traffic density correlates to air pollution levels,[4] the assumption can be made that areas with higher densities of daily traffic have higher levels of air pollution. Looking at county MI rates, we see variability within counties overall. With the traffic density overlaid on top, there is a preliminary idea of why some counties may be in the higher quintiles of MI rates particularly when comparing Marin to Contra Costa and Alameda counties - the higher quintiles tend to have more traffic density and therefore air pollution exposure.

2012 Myocardial Infarction Rates by County for the Bay area



2012 Myocardial Infarction Rates by County for the Bay area with Traffic Overlay



The asthma maps further exemplify this relationship. From the county choropleth map for asthma rates, an initial understanding of the relationship between asthma rates and location of highways is seen. As the data becomes more granular, this spatial relationship becomes more pronounced. The darker colored zip code regions run along the roadway systems. The overlay of traffic density layer corroborates this pattern. Darker regions of traffic density coincide with the higher quintiles of asthma rates. This pattern is especially well characterized by the East Bay region of the map.

From this array of choropleth maps, a spatial relationship between asthma rates and traffic density can be seen. However, the statistical relationship is not verified here. For MI rates there seems to be variation by county overall.

Limitations

This analysis is a preliminary look at current publicly available data for MI and asthmatic event rates in the Bay Area of California- which has not yet been performed to date. These results further add to the literature demonstrating a spatial relationship between air pollution levels and specific health outcomes.

Unfortunately, due to restrictions on access to point data for MI and asthmatic events, hot spot analyses could not be conducted for identification of statistically significant areas that are at highest risk for traffic related health outcomes. However, from the traffic density overlay maps, a better sense of which areas will most likely be highlighted through hot spot analysis can be grasped. Further analysis is necessary for deeper understanding of the relationships displayed here. Past research has documented a link between poor air quality exposure with the socioeconomic status of populations and specific ages i.e. children.[4,5,6] This analysis looked at rates of asthma and MI for all ages rather than stratifying by age and did not delve into socioeconomic variables. Age stratification will help elucidate the impact of air pollution on health outcomes, especially for asthma, and socioeconomic variables should be explored in any future research on this topic.

From these preliminary results further hypotheses to test would be the statistical relationship of asthma rates or MI rates and traffic density at the census or block group levels as well as exploring socioeconomic variables.

References

1.Bay Area Air Quality Management District. (n.d.). PM Box Scores. Retrieved from http://sparetheair.org/stay-informed/particulate-matter/pm-box-scores

2.Bind, M. A., Peters, A., Koutrakis, P., Coull, B., Vokonas, P., & Schwartz, J. (2016). Quantile Regression Analysis of the Distributional Effects of Air Pollution on Blood Pressure, Heart Rate Variability, Blood Lipids, and Biomarkers of Inflammation in Elderly American Men: The Normative Aging Study. *Environ Health Perspect*. doi:10.1289/ehp.1510044

3.Gordian, M. E., Haneuse, S., & Wakefield, J. (2006). An investigation of the association between traffic exposure and the diagnosis of asthma in children. *J Expo Sci Environ Epidemiol, 16*(1), 49-55. doi:10.1038/sj.jea.7500436

4.Gunier, R. B., Hertz, A., Von Behren, J., & Reynolds, P. (2003). Traffic density in California: socioeconomic and ethnic differences among potentially exposed children. *J Expo Anal Environ Epidemiol, 13*(3), 240-246. doi:10.1038/sj.jea.7500276

5.McEntee, J. C., & Ogneva-Himmelberger, Y. (2008). Diesel particulate matter, lung cancer, and asthma incidences along major traffic corridors in MA, USA: A GIS analysis. *Health Place, 14*(4), 817-828. doi:10.1016/j.healthplace.2008.01.002

6.Perlin, S. A., Sexton, K., & Wong, D. W. (1999). An examination of race and poverty for populations living near industrial sources of air pollution. *J Ex Anal Environ Epidemiol, 9*(1), 29-48.

7.Vaduganathan, M., De Palma, G., Manerba, A., Goldoni, M., Triggiani, M., Apostoli, P., . . . Nodari, S. (2016). Risk of Cardiovascular Hospitalizations from Exposure to Coarse Particulate Matter (PM10) Below the European Union Safety Threshold. *Am J Cardiol*. doi:10.1016/j.amjcard.2016.01.041

Data Sources: California Department of Public Health (2016), California Department of Transportation (2016), Census.gov (2016), ArcGIS version 10.3, Esri Redlands, California

Cartographer: Kaela Plank

May 5, 2016
PH 262
Thomas J. Stopka, PhD, MHS
Joel Kruger

Tufts UNIVERSITY