

Asthma and Air Pollution in LA County: Modelling Asthma Prevalence and Spatial Distribution of Manufacturing Industries

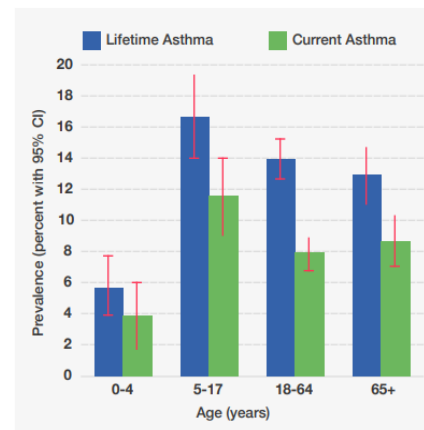
I. Problem Statement

Asthma is a chronic lung disease that affects the respiratory tract in children and adults. Asthma causes wheezing, shortness of breath, chest tightness, and coughing at night or early in the morning. The Asthma and Allergy Foundation of America estimates that 26 million people in America suffer from Asthma in 2018¹. It is a common and costly disease that has no cure. In the state of California, the California Department of Public Health estimated that 5.2 million people suffered from Asthma² in 2017. By age group, asthma prevalence is highest in the 5 to 17 age group. The graph on the right shows lifetime asthma (individuals diagnosed with Asthma) and current asthma (those suffering from or taking treatment for asthma). On both indicators, the 5-17 age group is the most vulnerable to contracting asthma.

There are three common types of Asthma: exercise-induced asthma, occupational asthma and allergy-induced asthma. Exercise-induced asthma is related to excessive exercising and can be triggered when the air is too hot or too cold. Occupational asthma is related to exposure to harmful chemical fumes, gases or dusts in the work place. Allergy-induced asthma is triggered by air-borne substances such as pollen, mold spores, or pet dander. Allergy induced asthma is common among the 5-17 age group.

There are four types of sources of air pollution that could trigger allergy-induced asthma: natural sources (volcanos, lightning, wildfires), area-based sources (livestock, fertilizers, oil and gas extraction, cities), stationary sources (industries, power plants, sewage treatment) and mobile sources (airplanes, cars, trucks, buses, and motorcycles). These sources release a variety of air pollutants into the atmosphere. Air pollutants can be broadly divided into three categories: criteria pollutants, air toxins, and biological pollutants. Criteria pollutants are regulated and monitored to improve air quality. These include carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter (PM), and sulphur dioxide. Of these, particulate matter which is of size 2.5 (also called PM 2.5) and ozone are of concern to human health and the warming of the planet. Air toxins are hazardous air pollutants who exist in the atmosphere in small

Lifetime and Current Asthma Prevalence by Age, California 2014
Data Source: CHIS 2014



¹ Source accessed on April 28, 2019 at <https://www.aafa.org/asthma.aspx>

² Source: Asthma Surveillance Report, California Department of Public Health, 2017

quantities but have the potential to harm human, animal and plant health. Sources of air toxins include motor vehicle emissions, solid fuel combustion, industrial emissions, and materials such as paints and adhesives in new buildings. Biological pollutants are due to microbiological contamination, and skin of animal and human skin.

In this research, I study the effects of proximity to manufacturing industries on prevalence of asthma. Manufacturing industries release several types of air pollutants such as ozone, particulate matter and hazardous air toxins. When manufacturing industries are located close to freeways, the combined effect of air pollution from the industry and mobile sources such as cars result in concentration of air pollutants in the local atmosphere. This has led to pollution reduction efforts that focus on areas surrounding freeways and manufacturing industries. In this paper I argue that policy efforts should consider wind direction and pollution reduction efforts should focus on areas that are downstream from where industries are located. I find that communities located downstream in the wind direction are faced with a triple disadvantage of high exposure to ozone, PM 2.5 and traffic pollution. The study concludes that the policy recommendation there should be additional focus on reduce pollution in downstream communities that are low income and at a much higher vulnerability of suffering from asthma.

II. Data Sources and Spatial Data Management

The context of the study is LA county. The main data source for the project the California Office of Environmental Health Hazard Assessment (OEHHA) agency's CalEnviroScreen³ Score. Starting in 2013 the OEHHA tracks and measures environmental pollutants and incidence of diseases for each census tract in the state of California. Based on these indicators the agency creates an index score. Indicators included in the score include levels of air pollutants such as ozone, PM 2.5, traffic, water pollution, toxic release etc. The dataset also provides data on socio-economic indicators such as median household income, proportion of population by race and age. Data from the CalEnviroScreen dataset on prevalence of asthma and three air pollutants – ozone, PM 2.5 and traffic – in LA county was the main data source for this study.

In addition to the CalEnviroScreen dataset, I also used parcel-level data on location of manufacturing industries in LA county. This data was accessed from the LA county tax assessor's open data portal⁴. Two time periods of CalEnviroScreen scores were used – 2014 and 2018. Information on manufacturing industries are found at the parcel-level. The tax assessor's dataset provides information on the address, assessed value, general use and special use of each parcel in LA county. Under general use, parcels are categorized as single family homes, multi-family units, industrial, institutional and vacant parcels. Parcels that are identified as industrial general use were used for mapping the manufacturing industries data layer. Data on freeways in LA county was obtained from the LA county GIS data portal⁵.

There were three spatial datasets on LA county used for this study:

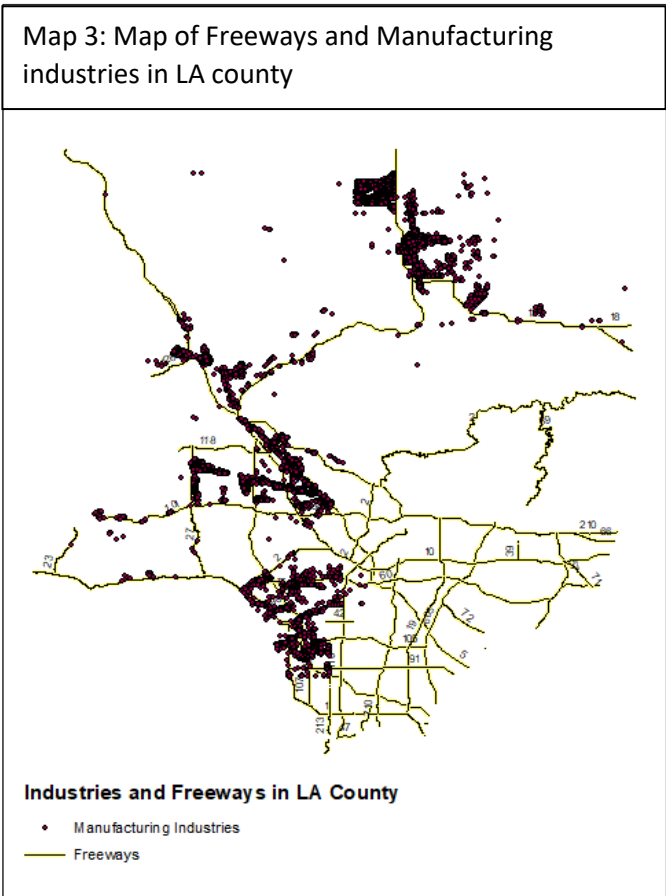
- a. Data on air pollution and asthma prevalence at the census tract level
- b. Data on location of manufacturing industries at the parcel-level

³ The OEHHA's CalEnviroScreen Score can be found at <https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30>

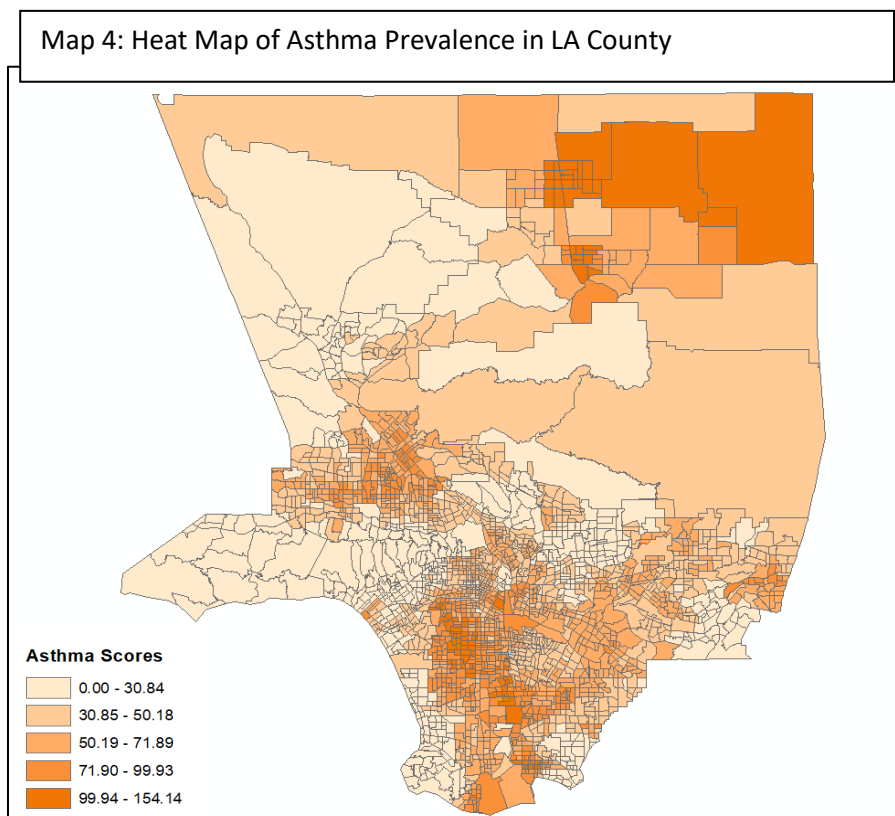
⁴ The LA county tax assessor's open data portal can be found at <https://data.lacounty.gov/browse>

⁵ The LA county GIS data can be found at <https://egis3.lacounty.gov/dataportal/category/theme/>

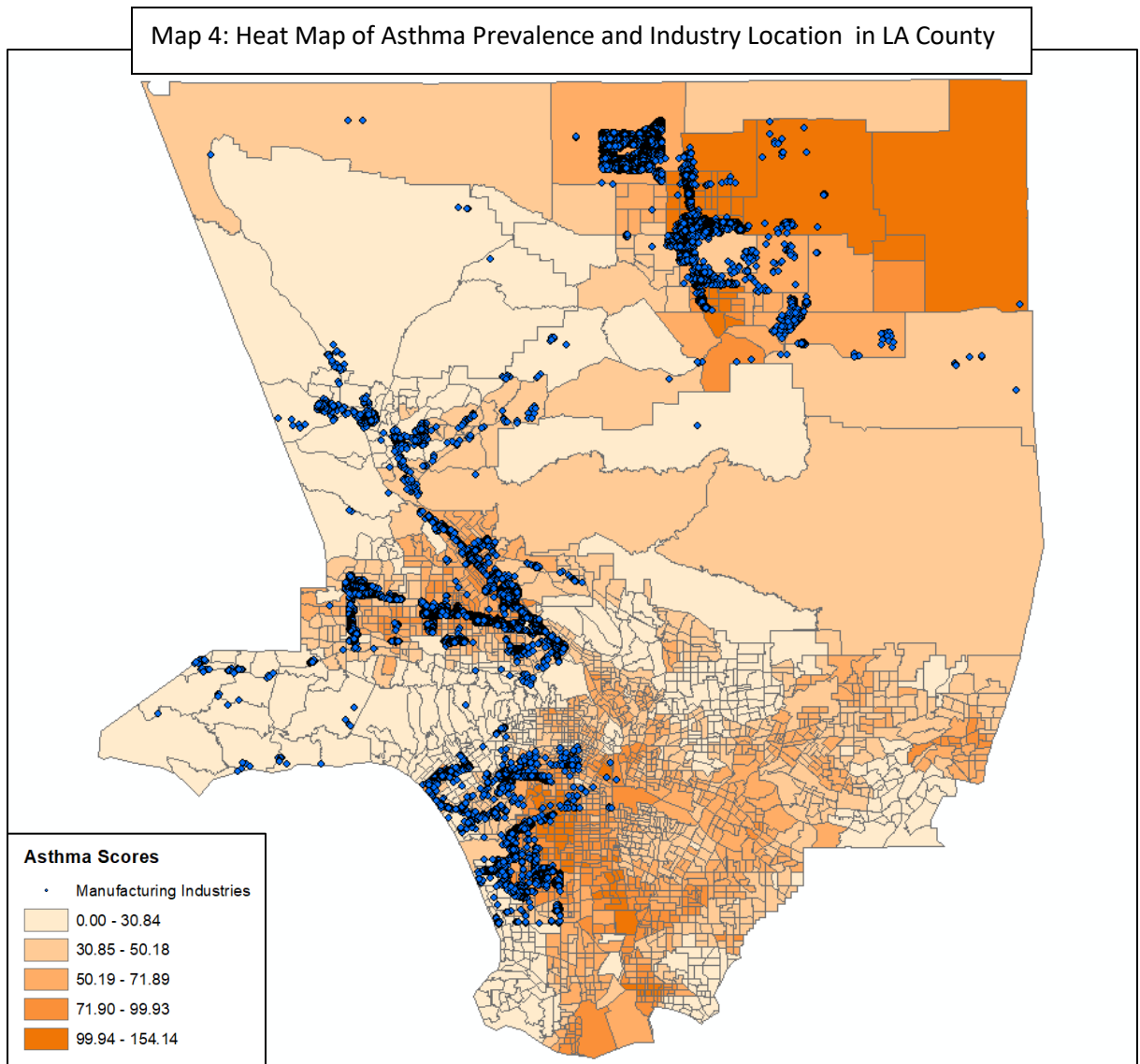
Overlaying the freeways data layer with (xy) point coordinates of manufacturing industries shows that most manufacturing industries are clustered around freeways. Map 3 shows location of manufacturing industries and freeways in LA county. There are 13,579 manufacturing industries in LA county. Types of manufacturing industries include food processing plants, heavy manufacturing, industrial, light manufacturing, lumber yard, and mineral processing. It is understandable that manufacturing industries will be located close to freeways since proximity to transportation networks is important for industries. However, this means that the level of air pollution in these locations is likely to be considerably higher. From map 3, one can notice three spatial clusters of industry and freeways – near the north-east corner, towards the south – west corner and towards the east. Reading maps 2 and 3 together shows that industry clusters also have a high density of census tracts indicating high population concentration in areas that are likely to have high air pollution.



Moving to asthma prevalence in LA county, map 4 is a heat map of the asthma score for each census tract in the county. We find that asthma scores are higher in the three clusters identified above. The north-east corner, the south-west corner and the east show a deeper shade of color indicating higher asthma scores and higher rates of asthma prevalence.

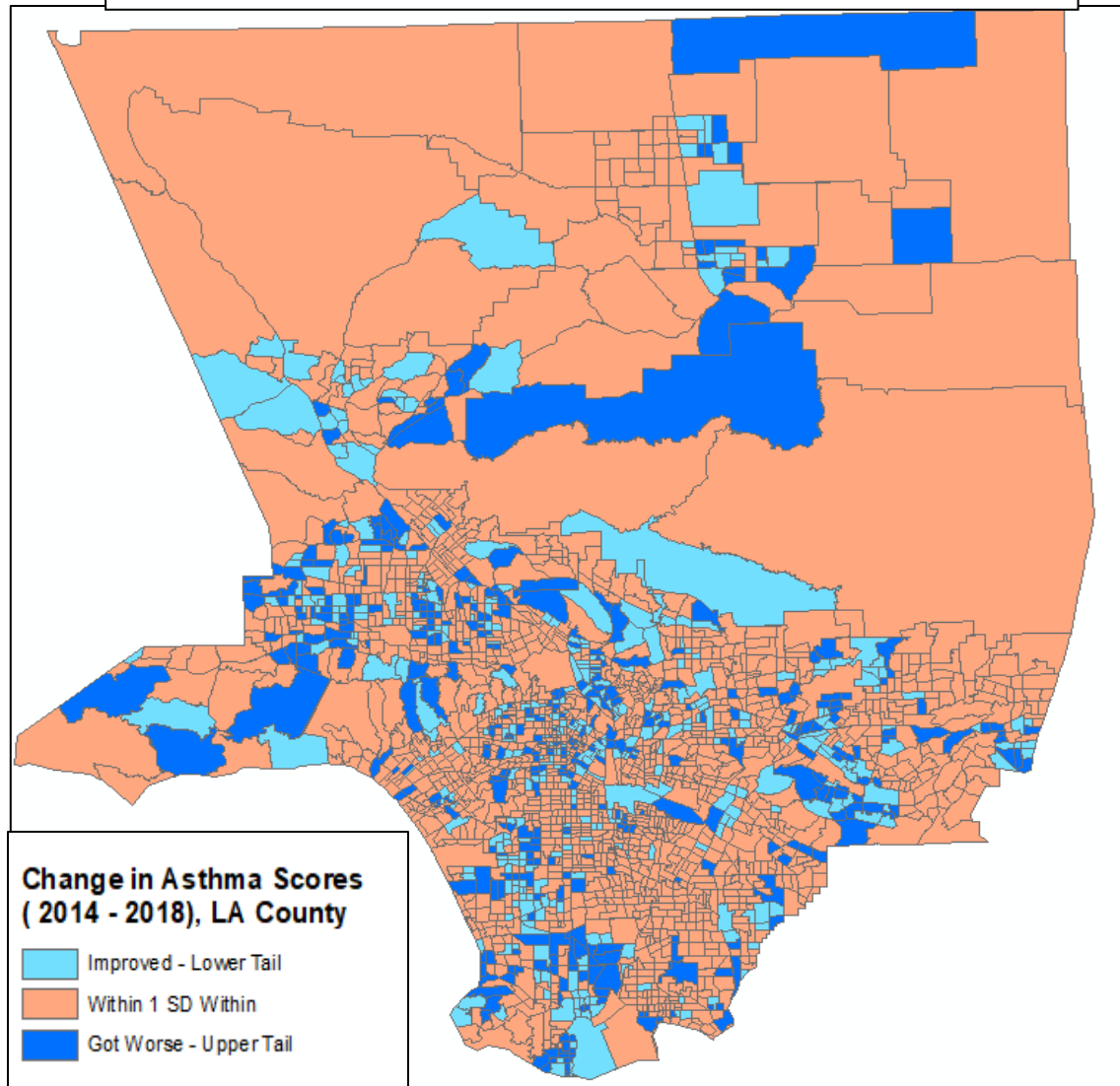


To confirm this observation, when we overlay the asthma scores layers with location of manufacturing industries, we see that darker shades that correspond to scores of 99 and above (out of a total of 155) are located close to manufacturing industries (map 4).



The descriptive analysis provided so far would lead us to believe that three clusters where industries are located are most vulnerable to asthma prevalence and therefore asthma related interventions should be targeted towards communities in these locations. However, when we look at change in asthma prevalence between 2014 and 2018, we find a slightly different pattern emerges. Map 5 shows census tracts that improved and those that got worse in asthma scores between 2014 and 2018. Census tracts that improved are those whose scores went *down* between 2014 and 2018 and census tracts that for worse are those whose scores went *up* between 2014 and 2018. One can see from map 5 that some areas with lighter shades in map 4 have gotten worse in map 5 and some areas with darker shades in map 4 have gotten better in map 5. This indicates that the pattern of proximity to industry and asthma prevalence may not be as straightforward as initially anticipated.

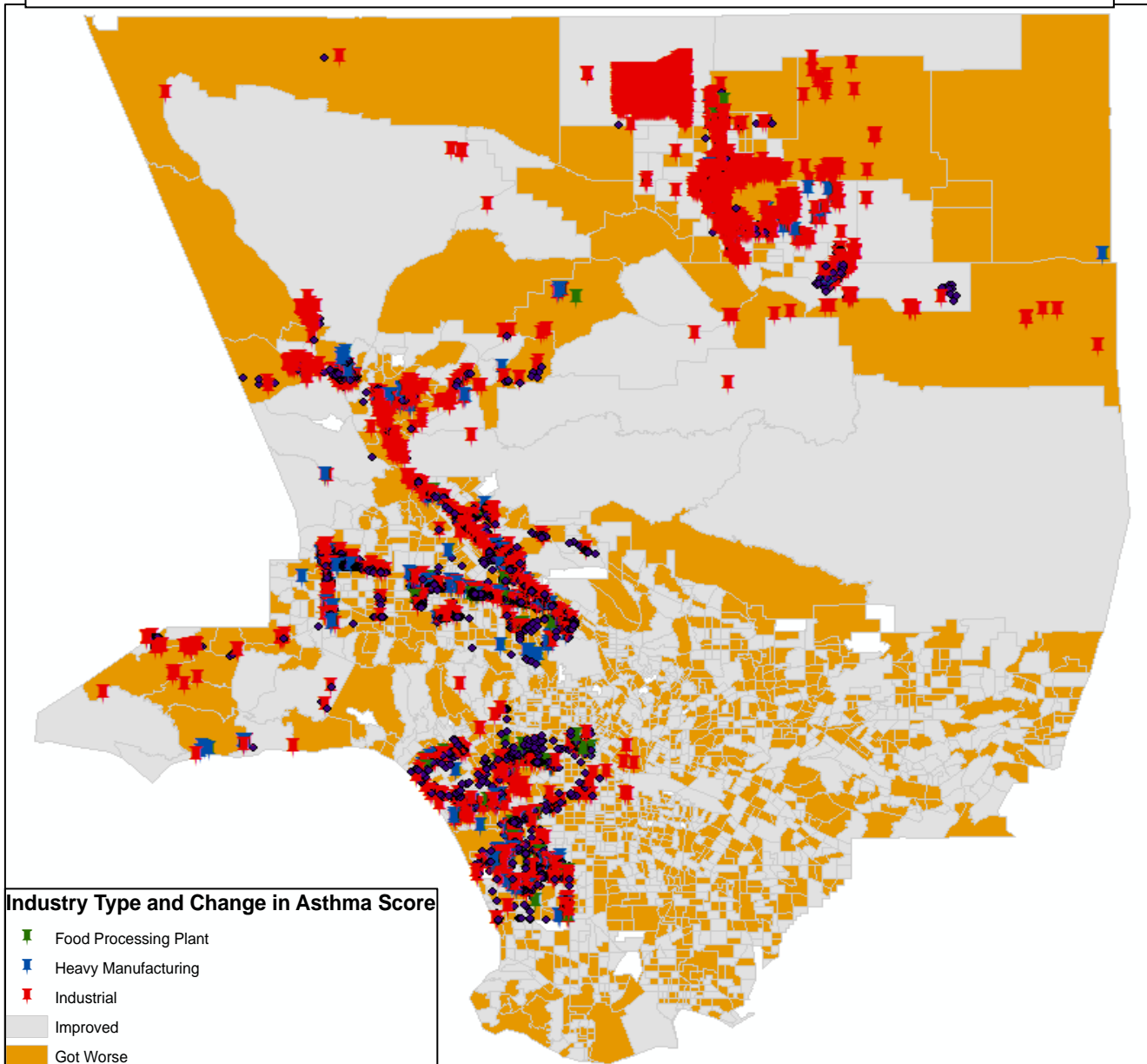
Map 5: Change in Asthma Prevalence between 2014 and 2018, LA County



To further investigate the phenomenon, I disaggregate industry use by type of industry (specific use) to find any spatial patterns of type of industry and asthma prevalence. By parcels, 0.49% are food processing plants, 2.36% are heavy manufacturing, 42.62% are industrial, 52.85% are light manufacturing, 0.36% are lumber yards, and 1.33% are mineral processing plants. Most industrial air pollution emissions are from food processing, heavy manufacturing and industrial plants. Light manufacturing, though the highest in number, usually include electric poles and other similar industries. Map 6 shows location of food processing plants, heavy manufacturing and industrial plants. We find a mix of all three industries across the industry clusters. No clear pattern emerges in spatial concentration of specific types of industries and change in asthma prevalence. Since disaggregation by industry type

does not yield results, I now turn to disaggregation by type of pollutant. I study the spatial pattern of three types of industrial pollutants – ozone, PM 2.5 and traffic pollution.

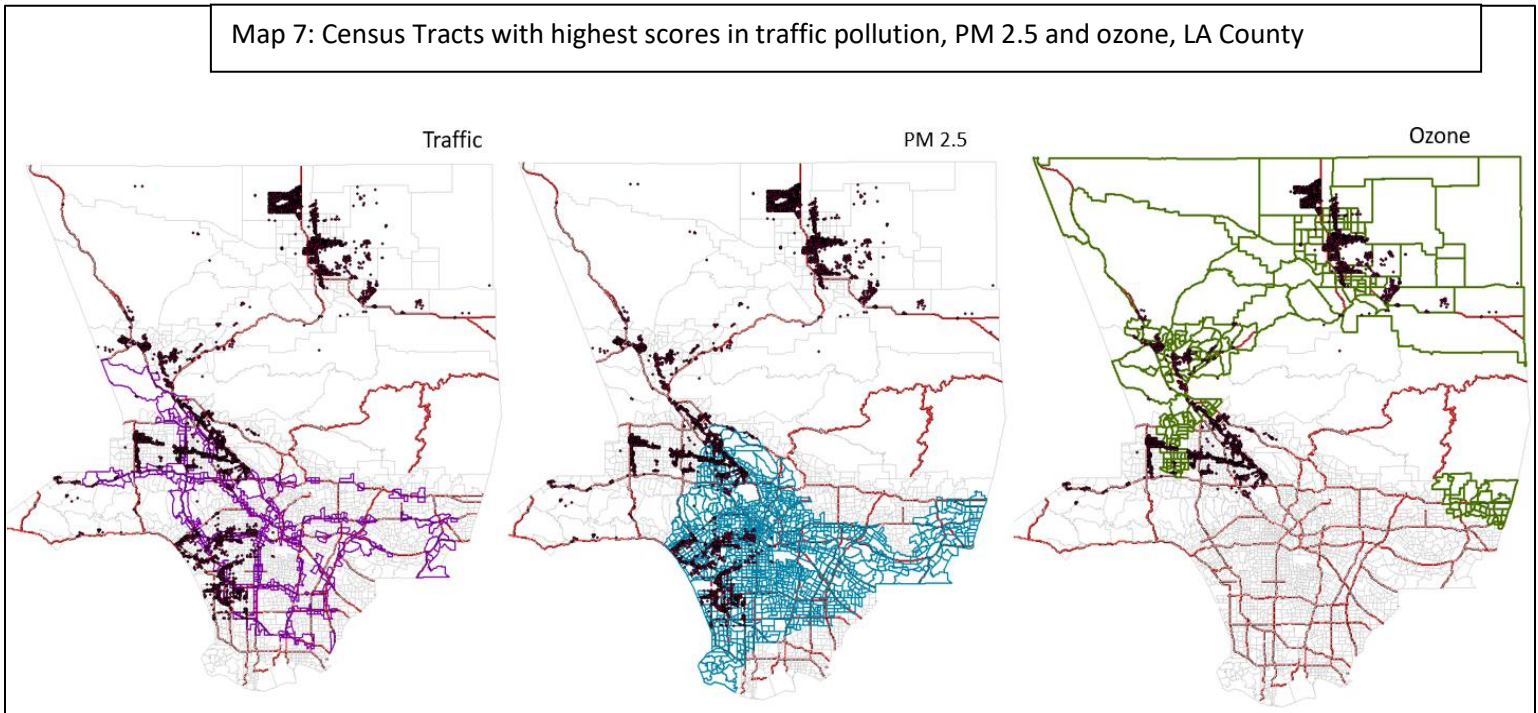
Map 6: Change in Asthma Prevalence between 2014 and 2018 and Type of Industry, LA County



Three common types of pollutants that tend to trigger asthma attacks in patients and increase asthma prevalence are ozone, particulate matter which is of size 2.5 mm and pollution from cars and other mobile sources due to congestion on freeways. Ozone causes warming of atmosphere which could trigger exercise-induced asthma and allergy-induced asthma. PM 2.5 is a fine air dust that enters the air through smog and dust. It is easily breathed in and retained in the lungs that could result in aggravating asthma attacks. Pollution from traffic increases both toxic air pollution and allergens in the air which increase the chance of asthma attacks. Map 7 shows the census tracts with highest scores in traffic

pollution, PM 2.5 and ozone in the CAEnviroScreen score. One can see that the highest scores for all three types of pollutants show significant spatial variation. Highest scores on traffic pollution are concentrated in tracts that are contiguous with freeways. The census tracts with highest scores in PM 2.5 are in the southern part of LA county while census tracts with highest ozone scores are located towards the northern side of LA county. To understand how type of pollutant affects asthma prevalence I create a spatial model that measures distance from industry (described in previous section.

Map 7: Census Tracts with highest scores in traffic pollution, PM 2.5 and ozone, LA County



The spatial regression model is given by the equation:

$$(\text{Asthma Score})_c = \alpha + \beta(\text{Type of Pollutant})_c + \rho(\text{Distance to Industry})_c + \lambda(\text{SE})_c + \varepsilon$$

Where the subscript c represents each census tract (the unit of analysis). β is the coefficient term for each type of pollutant, ρ is the coefficient term for the distance to industry variable, λ is the coefficient for the socio-economic variables that the model controls for and ε is the idiosyncratic error term. The spatial model is run for all three types of pollutants – traffic pollution, PM 2.5 and ozone. The model controls for several socio-economic factors such as median household income, poverty rate and unemployment rate of census tract. Ordinary least squares estimates are computed for the spatial models.

Findings: Triple-Disadvantaged Communities

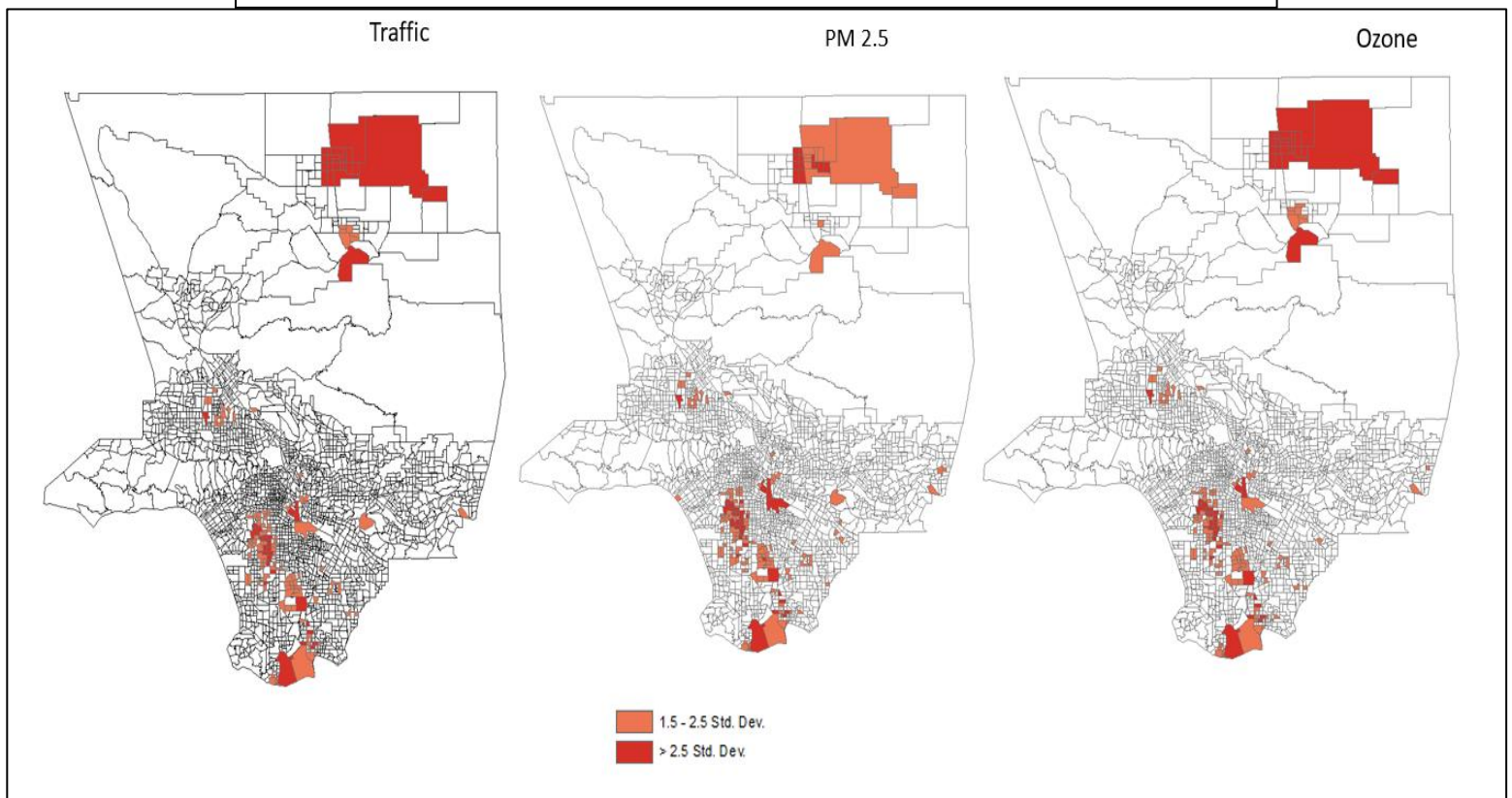
Based on the spatial model, I find that certain census tracts are systematically at a much higher disadvantage compared to other tracts on all three types of pollutants. I refer to these census tracts as triple disadvantaged communities. The analysis is based on a normal distribution of asthma prevalence as predicted by the spatial model. The normal distribution has a mean of 0 and a standard deviation of 1

on either side of the mean. Census tracts that fall on the left side of the normal distribution have lower than predicted probability of asthma prevalence while census tracts on the right side of the normal distribution have higher than predicted probability of asthma prevalence. Therefore, if a census tract is on the right hand side for all three types of pollutants, it has higher predicted probability of asthma prevalence.

Based on the descriptive data above, one would expect that census tracts that are close to manufacturing industries will be on the right side of the normal distribution or these census tracts have a high exposure to air pollution from the industries and are therefore highly vulnerable to asthma prevalence. The spatial model, on the other hand, introduces the distance from industry variable and asks the question is proximity to manufacturing a good predictor of asthma prevalence. If distance to industry matters for high asthma prevalence, we would expect census tracts close to industries will be on the right side of the distribution. Map 8 shows the census tracts that are 1.5 standard deviations and higher on the right side of the normal distribution. These census tracts have very high probabilities of asthma prevalence when distance to industry is included as a predictor. We find that some of these census tracts that not located close to either industries or freeways.

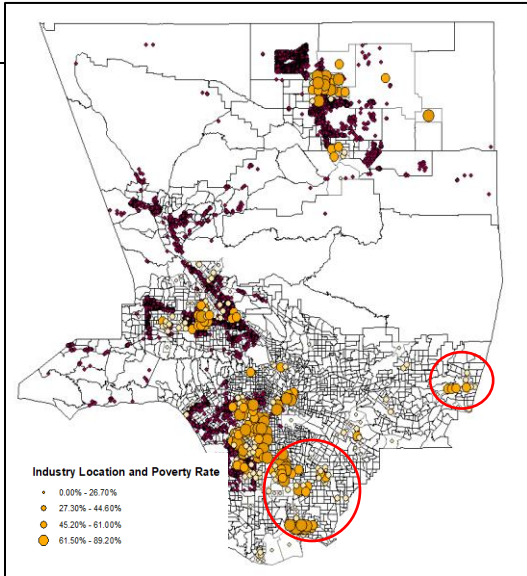
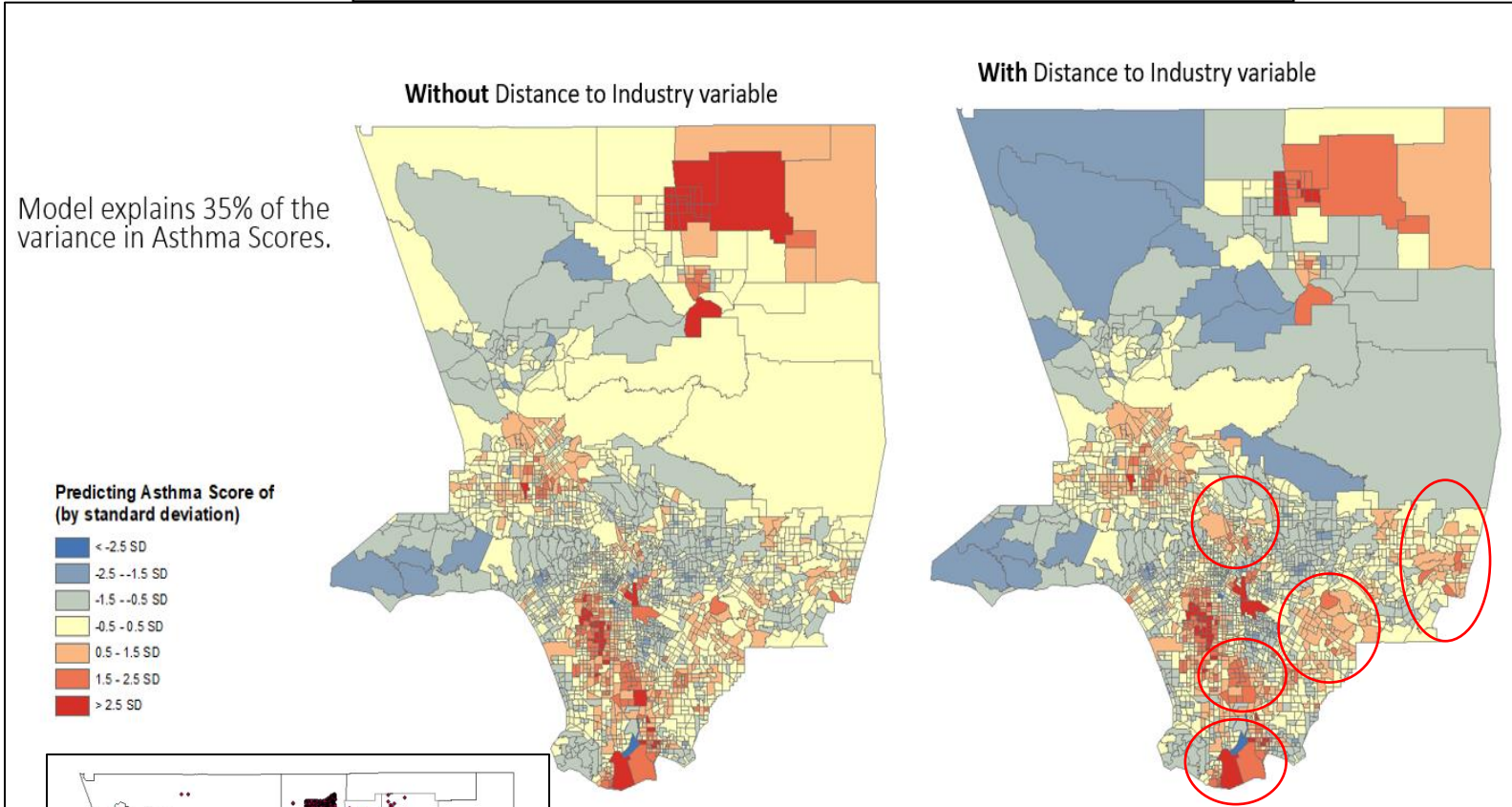
If we recall the three clusters from earlier, in addition to census tracts in the north-east cluster, census tracts in the south and east are identified as vulnerable to asthma prevalence. These census tracts are not close to any of the three industrial clusters. These census tracts are also consistently identified in models for the three types of pollutants. These results indicate that there needs to some factor other than proximity to manufacturing industries that is causing the high prevalence of asthma in these census tracts.

Map 8: Triple Disadvantaged Communities in LA County



The spatial model predicts 35% of the variance in asthma scores across all census tracts in LA county. Map 9 shows how the predicted asthma prevalence scores change when the spatial model is run without the distance variable and with the distance variable. When the distance variable is included the census tracts change their location on the normal distribution curve. Some census tracts shift towards the left tail of the curve while others move into the right tail of higher vulnerability. Map 9 shows five areas towards the south and south east of LA county that are farther away from the spatial location of industries but have high asthma prevalence. This shows that one would expect that asthma prevalence is likely to be high in census tracts located close to industries because of the increased exposure to air pollution in these areas. However, there are census tracts that are not close to where industries are located but also have higher than average asthma prevalence. The inset map shows that two of the five areas identified in map 9 are also have high poverty rates.

Map 9: Change in Predicted Asthma Prevalence Scores in LA County



IV. Conclusion

In this I investigated the relationship between asthma prevalence and proximity to industry. My specific question was whether census tracts close to industries had higher asthma prevalence than other census tracts. To investigate this question, I first conducted spatial descriptive analysis. Based on the descriptive analysis, I find that there are three clusters of industrial locations. Among these two clusters – those in the north east and south west have high asthma prevalence. I then disaggregated data on industries by type of industry to find any patterns between location of a specific type of industry and asthma prevalence. I look at three types of industries that have high air pollution rates – food processing, heavy manufacturing and industrial. This analysis does not yield any spatial patterns in terms that there is no discernible spatial concentration by type of industry.

I, therefore, turn to conducting an analysis of asthma prevalence and disaggregating on type of pollutant. I look at three types of pollutants – ozone, PM 2.5 and traffic. These three pollutants are commonly present in the air and are known to trigger asthma attacks. When looking at census tracts that have high scores on each type of pollutant, I find spatial variation in tracts. Tracts with high scores on traffic are located contiguous to freeways, those with high scores in PM 2.5 are located to the south of LA county and those with high scores in ozone are located to the north of LA county.

I investigate the spatial variation and type of pollutant by creating a new variable – distance to industry. Modelling the distance variable with type of pollutant, I find that certain census tracts have systematically high asthma prevalence across all three types of pollutant models. I refer to these as triple disadvantaged communities. Four communities are identified in the south of LA county that are not close to industrial locations but have high asthma prevalence.

I reason that an explanation for census tracts farther away from industrial locations to have high asthma prevalence is wind direction. Pollutants in the air, particularly pollutants such as PM 2.5, could be carried by wind to locations farther away and inhaled in higher concentrations by communities downstream from the industry. From the analysis, it appears that the wind direction in LA county is from west to south. Therefore, while industries are in the west, due to wind flows southward or eastward, communities in these areas are breathing air pollutants at a higher rate than usual resulting in higher than average asthma rates in these areas. The policy recommendation here is to target asthma reduction and rehabilitation efforts towards communities in the downstream wind direction in LA county.

V. Limitations of Study

The study has several limitations. First, data on industries is not complete. I was not able to identify industries in the south of LA county. This could be because of the way LA county tax assessors identify and categorize these industries. Second, a fine-grained analysis of type of emissions and type of industry is likely to provide more insights into vulnerable communities. For example, by disaggregating the types of pollutant emissions by food processing plants vs. industrial plants will help to arrive at the interaction of pollutant emissions and industry type. Such an analysis will contribute to creating industry-targeted emissions reduction policies. Such policies would add to the effectiveness of asthma reduction in addition to the area-targeted policies recommended in this study.