Demographic Analysis of Air Pollutant Exposure – Greater Seattle Area

Addendum

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Research Question:

Which communities in the Greater Seattle Area are within a hazardous distance of both stationary and mobile sources of pollution, such as the interstates and other major roads, and how does this increased exposure to pollutants impact their health?

Intro:

Pollution is present wherever there is urbanization and affects everyone in some form or another. We want to explore the relationship between pollution, demographics, and our health by looking at mobile and stationary sources of pollutants in the Greater Seattle Area (GSA). Mobile sources of pollutants include things like automobiles while stationary sources may be factories or any other source of pollutants that is set in place, as the name suggests. Looking at stationary and mobile sources allows us to assess the air quality of the GSA. By visualizing and analyzing this data we are able to find areas of interest where there may be an overlap of both mobile and stationary pollutants. Examining the health of people in these areas as well as their demographic make up is then important to study the relationship between these three factors and air quality. The complexity of this calls for an examination into the inequality that people in our areas of interest face when it comes to air quality in the GSA.

Washington state in general is an interesting area to study because it has some of the cleanest air in the country. As the largest population center in the state, the GSA feels like a place where this can be tested by observing the air quality above it and the people living within it.

Project Overview and Rationale:

We are studying the GSA, which we define as King, Pierce, and Snohomish counties. The GSA has areas that are highly urbanized with multiple major roads and set locations where pollutants are expelled into the air. These are areas with more mobile and stationary sources of pollutants near residencies and people. The GSA also has rural areas where interactions between mobile and stationary sources and people are potentially minimal. This is just as useful to study the relationship between pollutants and the population near them. The scale of our project is at the census tract level in order to be as specific as we can when we look at data for demographics and health as well as stationary points of pollutants. We are looking at the year 2014 because a multitude of data was released in this year regarding pollution in the GSA and because 2014 was a year when the GSA was seeing a boom in population and traffic.

The reason we have chosen to look at mobile sources of pollutants like vehicles on major roads for this project is because the GSA has notoriously congested interstates and highways in the highly urbanized areas and because a cocktail of pollutants is released into the air by most vehicles. We have chosen to study stationary sources of pollutants as well because of their potential to release a wider variety of pollutants into the air and their fixed location near communities.

For this project we want to establish a connection between air quality and environmental health disparity (if there is one) by analyzing the geography of air pollutants. This means taking into account where in the GSA air quality is at its worst and best and who is affected. The *who* is very important for this study because in order to understand environmental health disparity as it relates to air quality, we need to understand the people that are living inside the GSA. This means looking at characteristics like race and poverty of people throughout the region. Once this is done an examination of the health of our areas of interest can be carried out.

Methods of Analysis

Phase 1: Pollution Sources

1: Summary

In this phase, we will attempt to visualize air pollution from mobile and stationary sources in the Greater Seattle Area. That data required to map the precise amounts and locations of these pollutions does not exist. So, we must use proxy variables to estimate their scope and magnitude.

1.1: Mobile Sources

Automobile pollution is the most prolific mobile source of air pollution. So, to represent air pollution from mobile sources, we mapped traffic density on high-capacity transportation routes, namely interstates and highways. The WSDOT Statewide Travel and Collision Data Office has calculated Annual Average Daily Traffic (AADT) volumes for traffic counting locations all over the state. We used their 2014 calculations for this map.

Variable: Average Annual Daily Traffic Count
Unit: automobiles per day
Label: “Year_2014”
Measurement: Calculated by STCDO
Source: TPT Traffic Counts 2014 (WSDOT)
Geometry: Point (counting location), Vector (route)
Analysis
Mapping scheme: Color vector (route) by traffic density

1.2: Stationary Sources

Industrial facilities are a primary stationary source of toxic air pollution. These include larger facilities involved in industries such as manufacturing, metal mining, electric power generation, chemical manufacturing, and hazardous waste treatment. The EPA’s Toxic Release Inventory report publishes yearly datasets with toxics emissions / release data for facilities like these across the U.S. To represent pollution from stationary sources, we used data from the 2014 TRI.

To represent stationary sources, we mapped industrial on-site air emissions of toxic pollutants.

Variable: On-Site Air Emissions
Source: TRI (EPA)
Geometry: Point (facility location coordinates)

Analysis
Mapping Scheme: Color point (coordinate location) by total mass of on-site air emissions

1.3: Both Mobile and Stationary
Finally, we represented both sources together. We used color and shading to represent the volume and toxicity of air pollution at different locations, such as industrial facilities or highway segments. Additionally, we defined a buffer of 0.5 mi around the sources to delineate regions which we would predict to be most severely impacted by the pollution.
Variables: AADT and On-site Air Emissions
Explained previously
Analysis
Mapping: Combine previous two layers for one visual
Spatial Tools: Use buffer to establish at-risk/hazard zone

Findings:

By combining our mobile and stationary maps with buffers we can see that many of our stationary points follow the I-5 corridor from Seattle to Tukwila and then from Tukwila through the center of Kent. There also stationary points concentrated around the I-405 corridor north of Bellevue and around highway 509 near the Port of Tacoma. These are areas where there is a combination of both mobile and stationary pollutants.

Phase 2: Air Quality

2: Summary
After we have visualized the spatial distribution of air pollution sources, our next step was to visualize the air quality in the Greater Seattle area and point out spatial autocorrelation between air pollution sources and poor air quality.

2.1: Ambient Air Pollution
First, we mapped ambient air pollution using census tract level data from the 2014 National Air Toxics Assessment. The database contains measurements and modeled estimates for the ambient concentration of a variety of bio-hazardous air toxins, in micrograms per cubic meter. For each tract, we mapped the sum total of the mass/per volume of these toxins. We represented this data using a choropleth mapping scheme.
Variable: Ambient Concentration (micrograms / m3)

2.2: Hot-Spot Analysis
Next, we used Hot Spot analysis to discern whether there is a statistically significant spatial pattern in the ambient air pollution in the Greater Seattle Area.
Variable: Ambient Concentration (micrograms / m3)

2.3: Cluster Analysis
Then, we used Cluster analysis to try to differentiate whether a certain census tracts' ambient air pollution is more attributable to stationary sources or mobile sources.

Variable: Ambient Concentration (micrograms / m3)
Mapping: Compare with Maps 1.2 and 1.3

Phase 3: Health Risk

3: Summary
In this phase we assessed the health implications of exposure to pollutants. For each step below, we first used the map scheme and analysis on Exposure Concentration data, and then we used the map scheme and analysis on modeled Health Risk Estimates data.
We used health risk data from NATA, which provides estimates for Cancer Risk and Non-Cancer Risk and categorizes data by pollutant and by source. The scope of our study does not allow for us to examine or further study each pollutant chemical, so for this investigation we just mapped the data by source. Since we did not examine the data by pollutant or by differentiating between pollutants that are or aren't carcinogens, we focused instead on Non-Cancer Risk data. This provides a modeled hazard quotient, which is the ratio of potential exposure to a substance and the magnitude at which no negative effects are experienced. In this case, the substance in question is the pollutant.

3.1: Exposure Concentration and Health Risk
We used a basic choropleth mapping scheme to get a visual of the spatial distribution of pollution exposure throughout the Greater Seattle Area. We can tell the areas with the highest exposure cincentration were the northwest neighborhoods of Seattle, downtown Seattle, SeaTac, Kent, and the Port of Tacoma.
Variables: Exposure Concentration (micrograms / m3), Noncancer Risk (hazard quotient)

3.2: Hot-Spot Analysis
A hot-spot analysis allowed us to identify whether there is a statistically significant spatial trend in exposure concentration and health risk. Comparing both resulting maps suggests a causal relationship between pollution exposure and health risk.
Variables: Exposure Concentration (micrograms / m3), Noncancer Risk (hazard quotient)

3.3: Health Risk - Cancer
This is a choropleth map that displays the health risk in different areas of the region, measured in cancer incidence per million people. Areas with the lightest color have the lowest level of cancer incidence and areas with the darkest color have the highest level of cancer incidence.
Variables: Exposure Concentration (micrograms / m3), Noncancer Risk (hazard quotient)

3.4: Hotspot Analysis – Cancer

This is a choropleth map that presents the cancer risk hotspots in the region, with colors that correspond with seven different categories. Each category shows the confidence level of cancer risk in the area, and whether the area is designated as a hotspot or a cold spot. There is also a category that is indicated as “Not Significant.” The shade that is closest to dark blue correlates with the cold spot with the highest percentage confidence level, and the shade that is closest to dark red corresponds with the hotspot with the highest percentage confidence level.

Phase 4: Demographic Analysis

4: Summary
In this step we conducted an analysis of both the at-risk demographic and the demographic that is not at risk.
We started with a choropleth map that depicts Social Vulnerability Index data. This gives the viewer a high-level understanding and introduction to areas that are more susceptible to health risks, which means individuals located in these areas that are more vulnerable would undergo more health consequences if exposed to pollutants. Once we had this information as a starting point, we analyzed spatial patterns such as racial, ethnic and socioeconomic demographics. Finally, we drew attention to any areas that are more concentrated with certain groups using a cluster analysis.

4.1: Social Vulnerability Index
In this step, we mapped a variety of known social determinants of health. We began by mapping Social Vulnerability Index data from ATSDR using a choropleth mapping scheme, in order to get a “broad-strokes” idea of which regions are particularly vulnerable, and accordingly predict which places might be more exposed to pollution and at-risk for related health outcomes.

This is a choropleth map that demonstrates a social vulnerability index that correlates with this region and is measured with calculations defined by the ASTDR. The darkest shade of blue means the region is the highest level, and the opposite is true for the lightest shade of blue.

Variables: Social Vulnerability Index (ATSDR)

4.2: Cluster Analysis
This is a choropleth map that displays the social vulnerability hotspots in the region, with colors that correspond with seven different categories. Each category shows the confidence level of social vulnerability in the area, and whether the area is a hotspot or a cold spot. There is also a category that is labeled “Not Significant.” The shade that is closest to dark blue corresponds with the cold spot with the highest percentage confidence level, and the shade that is closest to dark red corresponds with the hotspot with the highest percentage confidence level.

After we developed a general idea of which regions in the Greater Seattle Area are more socially vulnerable, we moved forward and explored spatial patterns of some key social determinants. In this section, we specifically examined racial and ethnic demographics and socioeconomics.

Since we already have a choropleth estimation of regions that are particularly vulnerable, in this step we used Cluster Analysis to examine whether certain groups of people are concentrated in certain areas.
For any resulting maps with meaningful spatial clusters of certain groups, we compared them with maps from previous sections of pollution source locations (1.3), exposure risk (3.2.A / 3.3.A), and health risk (3.2.B / 3.3.B).

Variables:

- Racial/ethnic groups: Black, White, Hispanic/Latino, Asian, Native American, Native Hawaiian & Pacific Islander, etc. (% of population)
- Socioeconomic characteristics: median income (USD), unemployment rate (% of population), family poverty (% of population)

4.3 Socioeconomic Vulnerability
This is a choropleth map that displays the socioeconomic vulnerability in the region, and is measured in population proportion percentile, as defined by the ASTDR. The darkest shade of blue means the region is the highest-level percentile, and the opposite is true for the lightest shade of blue.

4.4 Socioeconomic Vulnerability Hotspots
This is a choropleth map that presents the socioeconomic vulnerability hotspots in the region, with colors that correspond with seven different categories. Each category shows the confidence level of socioeconomic vulnerability in the area, and whether the area is a hotspot or a cold spot. There is also a category that is labeled “Not Significant.” The shade that is closest to dark blue corresponds with the cold spot with the highest percentage confidence level, and the shade that is closest to dark red corresponds with the hotspot with the highest percentage confidence level.

4.5 Minority Populations
This is a choropleth map that shows the minority populations in the region, and is measured in population proportion percentile, as defined by the ASTDR. The darkest shade of blue means the region is the highest level of population proportion percentile, and the opposite is true for the lightest shade of blue.

4.6 Minority Population Hotspots
This is a choropleth map that shows the minority population hotspots in the region, with colors that correspond with seven different categories. Each category shows the confidence level of minority populations in the area, and whether the area is a hotspot or a cold spot. There is also a category that is labeled “Not Significant.” The shade that is closest to dark blue corresponds with the cold spot with the highest percentage confidence level, and the shade that is closest to dark red corresponds with the hotspot with the highest percentage confidence level.

Findings:

5.1

This image is a collection of maps, displaying air pollution concentration hotspots and hazardous zones around pollution sources, and their health ramifications through variables such as exposure risk hotspots and cancer risk hotspots. Our research shows that a substantial part of the west coast is a hotspot for toxic pollutant concentration, with the highest percentage confidence level of 99%. This statistic means that the area has a high occurrence of toxic pollutants. The 0.5 mile hazard buffers surrounding pollution sources are also extremely prominent on the west coast, and very closely aligns with the area that has the hotspot with the highest confidence level for toxic pollution concentration. It is significant to note that exposure risk hotspots and cancer risk hotspots with the highest confidence level, meaning these areas have the highest occurrence of exposure risk and cancer risk, also line up very closely with the area that has the most occurrences of both toxic pollutant concentration and hazardous areas. This suggests that there is a correlation between areas high in toxic pollutants and areas high in exposure and cancer risk.

5.2 Comparing Air Pollution Hotspots with Indicators of Social Vulnerability

Our final image has our maps demonstrating the relationship between air pollution concentration hotspots and multiple indicators of social vulnerability. The indicators we chose to examine are socioeconomic status, household composition and disability, minority status and language, and housing type and transportation. Our findings show that the central urbanized core of the GSA is a hotspot for toxic pollutant concentration and has the highest percentage confidence level at 99%. This means that the area has a high occurrence of toxic pollutant concentration. Next, examining the different maps that designate different types of social vulnerability shows us more information about how areas high in air pollution concentration correlate with areas high in social vulnerability. A noteworthy pattern is that the western portion of the GSA has a hotspot with a 99% confidence level, or high occurrence, of minority status and language, and housing type and transportation. Moving slightly to the east, that vertical layer of land is a stark contrast, with cold spots at the 99% confidence level. This means that these areas have low occurrences of both attributes. An interesting pattern regarding socioeconomic status and household composition and disability, is that the northeastern part of the GSA is a cold spot with a 99% confidence level. This means there is a low occurrence of disability and socioeconomic status. This area also happens to be a much more rural part of the GSA. The southwestern part is the opposite, in the sense that it is a hotspot with a 99% confidence level. There are high occurrences of these attributes in this area. Circling back to the map displaying air pollution hotspots, we can see that the prominent hotspot of air pollution concentration in the core urbanized part of the GSA has different relationships with social vulnerability indicators. An area high in air pollution appears to also be high in the prevalence of minority status and language, and housing type and transportation. This same area seems to be split into northeastern and southwestern aspects in both our socioeconomic status map and household composition and disability map, meaning there are low occurrences of these variables above that divide line and high occurrences below the divide line. This suggests that there are additional variables that are also having an impact on these social vulnerability indicators.

Conclusion:

We set off to explore the Greater Seattle Area's relationship with air pollutants. We wanted to see how mobile and stationary sources in specific affected the residents of the GSA so we mapped out where these sources were located and their immediate reach. This showed us that areas across the region were within a close range of a source, mostly because of the mobile sources (in our case roads with large amounts of automobile traffic) are inevitable in a region like the GSA. Some areas that fall within the vicinity of both sources were observed in various areas like in central Kent, for example. By observing the demographic make up of the GSA and running analysis on different variables we were able to figure out what the GSA's population looks like and where the vulnerable areas are located. We found that when it came to ethnic makeup, minorities within the urbanized portion of the GSA were more likely to be in areas with higher exposure risk to pollutants and in areas where hotspots for cancer incidents exist. Areas with higher cases of cancer incidents were also near some areas with a combination of mobile and stationary pollutant sources. The central Kent area is a location of great interest. There are higher incidents of cancer here, there are people who fall into a vulnerable category, and it is an area with a combination of mobile and stationary sources of pollutants. On the opposite side of the spectrum. One area that faired better when it came to cancer incidents, proximity to pollutant sources, ad vulnerability was Anderson Island in southwest Pierce County. This area is sparsely populated compared to other areas of the GSA. We cannot say for certain that mobile and stationary sources are the direct cause for things like increased cancer incidents and social vulnerability in areas of the GSA. However, we have observed that there is often overlap in the areas most affected by the variables we have looked at.

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