

## **The Economic Impact of Air Pollution Related Diseases on West Oakland**

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### **ABSTRACT**

Air pollution has been a large problem for the residents of Oakland, and West Oakland experiences the highest concentrations of air pollution in Alameda County. Although there is a plethora of research on PM2.5 concentrations, respiratory diseases, and death rates, there is nothing concrete on the economic impacts as a result of the air pollution. Therefore, using BenMAP, I wanted to estimate the economic impacts of the air pollution in West Oakland. I chose West Oakland as they suffer the harshest concentrations of the air pollution. Using averages of hospital admissions and mortality valuations from outside studies and the incidence rates found from BenMAP, I was able to estimate the economic impacts of air pollution in West Oakland. I found average incidence rates of Emergency Visit (EV) for Asthma = 127.4422, Hospital Admissions (HA) for All Respiratory Diseases = 167.1933, HA for Asthma = 14.8670, and Mortality = 476.4446. As for the valuations, the average cost of EV for Asthma is \$400, the average cost of an HA for Asthma is \$5,000, the average cost of HA for Respiratory Diseases is \$9,700, and the average cost of a Mortality is \$6 Million. The valuations were found from different research. Knowing how much money air pollution costs can be a big deciding factor in implementing change or policy to improve air quality conditions.

### **KEYWORDS**

BenMAP, particulate matter 2.5 (PM2.5), health impacts, estimates, hospital valuations

## INTRODUCTION

Since the dawn of time, humans have constantly been at odds with the natural environment. However, with the rise of machination and technology, as nature was replaced with our own construction, the traditional threats to our safety no longer take the form of massive predators or natural disasters. Now, they take shape from the environment that we've constructed, and one is air pollution. The World Health Organization (WHO) highlights air pollution as the greatest environmental risk to human health (Ritchie & Roser, 2017). Much like spears and stones against towering creatures, policy efforts and future policy actions have succeeded in reducing particulate matter (PM) in North America and Europe (West, 2016). Unfortunately, adverse health effects are still found at lower levels of air pollution (Liu, 2019). The plethora of health effects that air pollution has is one of the biggest reasons that the WHO considers air pollution the greatest environmental risk to human health.

Because air pollutants take a variety of forms, there are a variety of human health effects that can occur. Air pollution has both acute and chronic effects on human health, affecting a number of different systems and organs (Kampa & Castanas, 2008). Some of these health effects include increased respiratory symptoms, decreased lung function, increased cardiopulmonary (heart and lung) disease mortality, and increased hospitalizations for respiratory and cardiovascular disease (Bernstein & Alexis, 2004). These symptoms and diseases can take form as heart disease, lung cancer, acute respiratory infections in children and chronic bronchitis in adults, aggravating pre-existing heart and lung disease, or asthmatic attacks (Kampa & Castanas, 2008). Consequently, research done over a 30-year period across 652 cities in China showed a strong correlation, enough to link air pollution to premature death (Liu, 2019). In other words, areas with high air pollution result in high mortality rates or lessened life expectancy. In fact, the WHO attributes worldwide ambient air pollution to 29% of all deaths and disease from lung cancer, 17% of deaths and disease from acute lower respiratory infection, 24% of all deaths from strokes, 25% of all deaths and disease from ischemic heart disease, and 43% of all deaths and disease from chronic obstructive pulmonary disease (WHO). One of the places that suffer from and is constantly exposed to air pollution is Oakland, more specifically West Oakland.

The people in West Oakland largely suffer from the air pollutant black carbon or black carbon particles (BCP). These are classified as particulate matter, or PMs. BCP is a soot emitted

from diesel engines, which are used by the ships from the port and the trucks on the highways that go through West Oakland (EDF, 2018). BCP is closely related to adverse health outcomes such as cancer, cardiovascular and respiratory disease (Janssen, 2011). In the West Oakland community, hourly BCP concentrations measured at residential sites were 10% and 30% lower than those measured near highways and truck routes respectively, and ~70% greater than those measured at upwind sites (Caubel, 2019). As West Oakland is majority African American and the hills, where not a lot of the BCP pollution reaches, is largely white, it is not surprising that the life expectancy of African Americans was 73 years old and white people had a life expectancy of 81.6 years (City of Oakland, 2018). This big social problem is an example of environmental racism. This paper and research will take existing data and compile it to find the burden of air pollution on West Oaklanders.

There is a lot of existing, outstanding, and thorough research done on BCP and the concentrations of the pollution/pollutant in West Oakland, but there is a gap in information. There are no estimations or anything explicit about the cost of healthcare due to the air pollution in the area. There is little information about the types of diseases affecting West Oakland. Lastly, there is little published knowledge about what options there are for people living in West Oakland to pursue to mitigate the effects of air pollution and BCP. This gap in information is important because having tangible analyses and estimates of the costs that people suffer will make the issue of air pollution more concrete to law and policy makers. This information can be used, in addition to other standing evidences and research, to help policy or law makers make decisions that save Oaklanders large healthcare costs due to air pollution.

Therefore, my central research question is, “What is the burden of air pollution on the residents of West Oakland?” From there, I have three sub-questions. They are:

1. How does the burden take shape in the form of disease?
2. What are the healthcare costs due to the air pollution?
3. Are there any lifestyle changes that West Oaklanders must make because of the air pollution?

As most of my project will rely on compiling and analyzing existing data, there is no appropriate testable hypotheses that can be made. However, in order to answer the CRQ and the sub-questions, I will learn how to utilize BenMAP to answer sub-question 2 and gather enough primary resources

to answer sub-questions 1 and 3. Due to the high concentrations of air pollution in West Oakland, I expect to find that healthcare costs are high from respiratory related cases.

## **Background**

The residents of West Oakland spend every waking moment of their lives being choked and strangled by an invisible villain. It has led to a plethora of health risks and burdens on the West Oakland population (Davis, 2018). The largest burden, across all age groups, is the asthma hospitalization and emergency department visit rates, which are almost 2 times higher in West Oakland compared to the entire county (West Oakland RAC, 2015). On top of the doubled asthma rates, cancer, heart disease, stroke, and chronic lower respiratory disease make up the top five leading causes of death and in total are responsible for more than half the deaths in West Oakland (Davis, 2018). These cumulative health impacts have hurt and lowered the life expectancy of the community so much, that it has been comparable to that of North Korea (CIA World Factbook, 2011). If you haven't guessed it by now, the problem is air pollution.

The pollution problem in West Oakland has been ongoing for years. A study done by the California Air Resources Board found that West Oakland residents are exposed to the highest concentrations of diesel pollution (3 times higher the average background levels in the Bay) back in 2008 (EDF). This diesel pollution comes from the Oakland Port, the highways, and the other industrial areas around West Oakland (Fisher, 2006). The pollution is primarily composed of a particulate matter known as black carbon (BC), which is a product of combusting diesel fuel (Caubel, 2019). Because ships and trucks use diesel as fuel, it makes sense why BC is most closely looked at when analyzing pollution in West Oakland. Despite being a noticeable and heavily researched back problem for more than a decade, solutions to combat the problem on a government-level are really only kicking up now.

The solution that was passed in California legislature back in 2017, Assembly Bill 617, requires new community-focused actions that reduce air pollution and improve public health in areas disproportionately affected by pollutants (Smith, 2018). Several things are planned, mainly targeting what can be fixed, the highway and trucks (Rusby, 2019). These planned strategies involve implementing and using zero-emission trucks, rerouting truck routes, relocating truck yards away from residential areas, and moving out some industrial facilities from West Oakland.

It is no doubt a great thing that West Oakland is undergoing change to combat air pollution, but these are changes that are planned for 2025 and 2030 (5-year and 10-year time frames), and even then, these changes are considered ambitious (Rusby, 2019). To be fair, moving around infrastructure is not easy, but when these concerns were being brought up years ago, the city should have paid some attention. Now the residents need to suffer for another decade until the skies of West Oakland become bluer.

Something could be said here about environmental and structural racism, but as my project pertains to the economic burden of air pollution in West Oakland, I thought that it was not my place to incorporate such a heavy topic on top of a work heavy question. Though, if one would like to know more, there is a lot of great research out there that speaks of environmental racism and structural racism in West Oakland.

## METHODOLOGY

I will use BenMAP in order to determine the economic burden of air pollution on residents in West Oakland. BENMAP is short for Environmental Benefits Mapping and Analysis Program. It calculates the economic impact of air pollution. Right off of its website, it says, “The BENMAP-CE tool estimates the number and economic value of health impacts resulting from changes in air quality...” (EPA). It works by using data from published epidemiology literature and encompasses, “modeled or monitored air quality changes, population, baseline incidence rates, and an effect estimate.” It then uses that data and multiplies it by the average admission cost of a hospital visit, medical expenses, and lost work for the area.

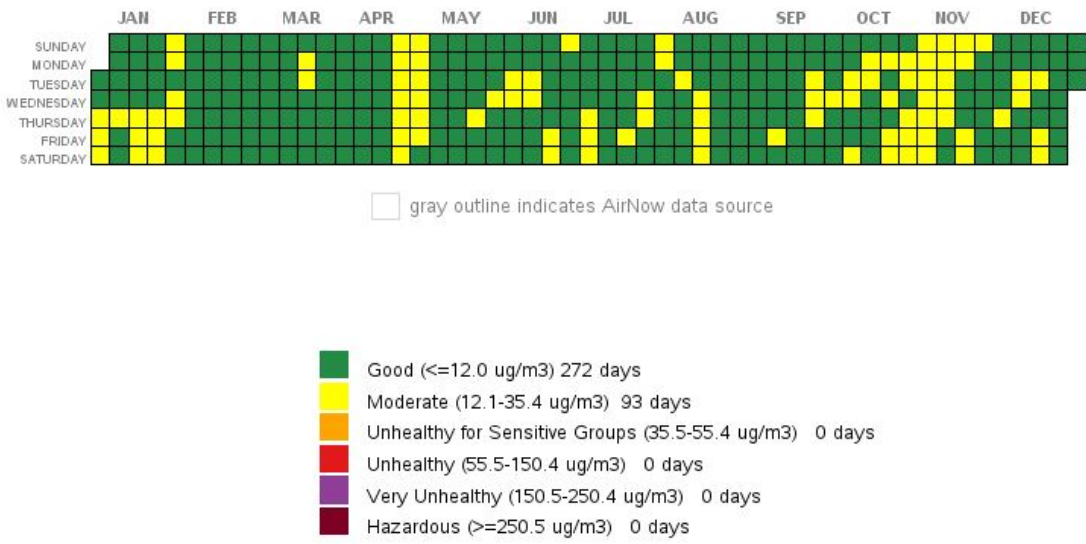
This tool is perfect for the research question. I want to look at the economic burden of air pollution in West Oakland. This program does exactly that. There are some problems with the program, mainly the difficulty in using it, but that is a problem that can be quite literally tackled head on. A greater breakdown of how BenMAP works will be introduced in the next section, Methods.

## METHODS

### BenMAP

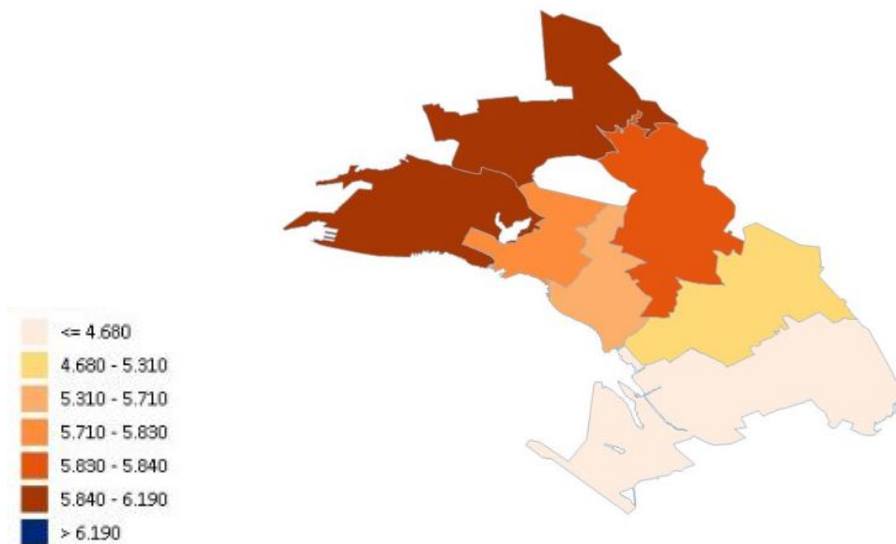
To do this study, I am going to be utilizing BenMAP-CE, which is short for Environmental Benefits Mapping and Analysis Community Edition. To summarize, it is an open-source computer program that calculates the number and economic value of air pollution-related deaths and illnesses that incorporates a database that includes concentration-response relationships, population files, and health and economic data needed to quantify these impacts (EPA). The figure below gives a simplified version of how it works.

However, in order for BenMAP to draw these conclusions, it requires certain pieces of data and information. The first is modeled or monitored air quality changes. In other words, this is the air pollution or air quality data. The air pollution data that I used tracked the concentrations of fine particulate matter, which is PM2.5. This data is found on the EPA’s website and the AQS data is that of Alameda County in 2019. I wanted to use the most recent full year of Alameda County for two reasons. The first is that West Oakland is in Alameda County, which is my area of interest. The second is related to the signing of Assembly Bill (AB) 617, which was signed in 2017. I wanted to show in the most recent full year how bad the air quality conditions still were, even though changes were being made. Figure 1 shows the entirety of Alameda County, but the air quality condition, which in the metadata can be separated so that we look at the area of interest, is much worse in Oakland.



**Figure 1. EPA air quality index data of Alameda County in 2019.** This is one method of visualization that the EPA offers for looking at AQI data. We can download the metadata for the values and everything that we need so that it can be formatted and exported into BenMAP.

The second piece of data is population. The population is gathered from PopGrid, which is a program that collects census data from 2010, which is easily implemented into BenMAP. The third piece of data is the baseline incidence rates and valuation data. This is the rate at which members of the population go to the hospital during the same time frame per x amount of people and the estimated health costs or formulas. The valuations were taken from two different studies. The average cost of EV for Asthma is \$400, the average cost of an HA for Asthma is \$5,000 (Brandt 2012), the average cost of HA for Respiratory Diseases is \$9,700, and the average cost of a Mortality is \$6 Million (Lee 2012). On the other hand, the incidence data was found on the open dataset site of Alameda County. The final component where everything fits in is the shapefile data. This shapefile data is used as a skeleton for BenMAP so that it can return an accurate estimate of all the three data. The shapefile data used was the Oakland Council Districts shapefile data, which was also drawn from the open dataset site of Alameda County. The combination of the shapefile data and the air pollution data can be seen in Figure 2.



**Figure 2. Oakland Council Districts shapefile data with pollution data.** The numbers on the left are the delta levels. The higher the concentration of air pollution, the darker the shade. The two darkest areas on the shapefile map is West Oakland. This is taken from BenMAP.

The purpose of the data analysis is to look at the economic value of air pollution-related deaths and illnesses that BenMAP provides to quantify the burden that West Oaklanders face due to air pollution. The type of data analysis is going to be qualitative. In other words, I am going to be drawing conclusions from the results of the BenMAP program and other outside research about

the burden and situation of West Oakland. By utilizing BenMAP and research collection, I can return and show the reality of the West Oaklanders.

## RESULTS

### BenMAP incidence and valuation estimates

As shown in Table 1, through BenMAP and the valuation equations, I was able to estimate the incidence and costs of the ER Asthma, HA All Respiratory, HA Asthma, and Mortality. For clarification, ER is emergency room, HA is hospital admission, and all respiratory is all respiratory related diseases or illnesses. The incidence means of each of the four categories in the same order are 127.4423 cases, 167.1933 cases, 14.8670 cases, and 476.4446 cases. The following valuations are \$50,976.92, \$1,621,775.01, \$74,335, and \$2,858.6676 million. I calculated the means, but in Table 1, the results are all shown individually where applicable. Based on the estimates, the people of West Oakland are losing millions of dollars due to air pollution related illnesses.

**Table 1. BenMAP incidence and valuation estimates of air pollution illnesses.**

Endpoint	Start Age	End Age	Incidence Mean	Valuation
Emergency Room Visits Asthma	0	17	30.52424	12,209.70
Emergency Room Visits Asthma	0	99	159.7483	63,899.32
Emergency Room Visits Asthma	0	99	159.7483	63,899.32
Emergency Room Visits Asthma	0	99	159.7483	63,899.32
HA All Respiratory	65	99	167.1933	1,621,775.01
HA Asthma	0	17	6.288776	33,443.88
HA Asthma	0	64	23.44528	117,226.40
Mortality All Cause	30	99	473.6318	2841.7908 Million
Mortality All Cause	25	99	479.2573	2875.5438 Million



## Research

According to the Community Air Protection Program in West Oakland, among a broad list of air pollution related diseases and mortality, 4 of the top 7 were air pollution related diseases. It found that cancer was 22% of all deaths, heart disease was 20%, stroke was 7%, and chronic lower respiratory disease was 5%. This means that 54%, or more than half, of the leading causes of death in West Oakland are due to air pollution-related illnesses. These are how air pollution takes form in the shape of illnesses and diseases.

There are also actions being taken to combat the air pollution in Oakland. The majority of the movement and actions come from the passed AB 617. The state government, local government, and the residents of Oakland work together in order to implement change. However, this change takes time. The plans to introduce ways to combat air pollution have 5-year plans and 10-year plans.

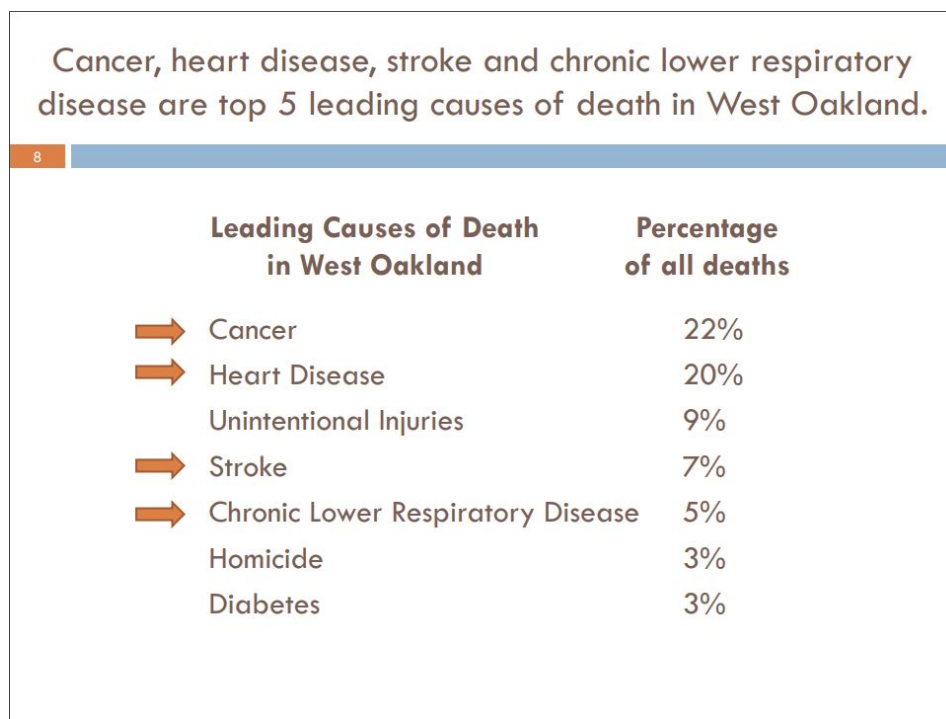
## DISCUSSION

There is a lot of research already done on air quality, air pollution, and health in Oakland, but there are really no specifics in regards to the healthcare costs of air pollution in Oakland. My results fill that gap in information. The results illuminate the CRQ and SQs about the burden that air pollution has on West Oakland. The two common themes that really unite the SQs are environmental racism and air pollution costs. As a quick reminder, my CRQ was, “What is the burden of air pollution in West Oakland?” and my SQs were, “What air pollution related diseases are affecting West Oakland residents?,” “What is the economic impact of healthcare costs due to air pollution?,” and “Is there anything being done to combat air pollution in West Oakland?.”

### Environmental racism

Although Oakland as a whole has been suffering from air pollution, due to its industrious areas, the highways, and the Port, it is mostly condensed in West Oakland. “Coincidentally,” 84% of the people who live in West Oakland are a minority, with 44% of the entire population being

Black (ACPHD 2018). Furthermore, the leading causes of death in West Oakland are cancer (22%), heart diseases (20%), unintentional injuries (9%), stroke (7%), and chronic lower respiratory disease (5%) (ACPHD 2018). We can see the effect of these diseases and the air pollution by comparing the life expectancy of West Oakland to the rest of Alameda County. The life expectancy of West Oakland is around 75 years, and that of Alameda County is around 82 years. When breaking down life expectancy into African American, White, Latino, and Asian, African American life expectancy is the only one that is under the average in Oakland and West Oakland. There is clearly a problem here, but the effects are more than just location based.



**Figure 3. West Oakland causes of death.** It was determined that more than half of the causes of death were due to or related to air pollution. The data was drawn from the Alameda County Public Health Department.

For years, minority populations have been struggling in Oakland, and a part of that comes from poor air quality. Where you live predetermines so much about your life, and an area with poor air quality can set you back very much with healthcare costs and higher chances of dying. This is only a small part in what contributes to environmental racism, the zoning, the air quality, and the numbers. Black people are repeatedly shown to have lower life expectancies and live in areas that contribute to that. That is not to say that we need to kill more white people to make

things even, but we need to plan cities and zone correctly so that point sources of pollution that accumulate in areas that have historically been racist with redlining practices only affect and hurt minority communities like West Oakland.

### **Air pollution costs**

Based on results, air pollution is a huge problem that is a constant drain of money from Oakland families. It becomes a real problem that does not just affect the health of members in West Oakland, but can also do some real damage to the overall livelihood of households. Inhalers need to be refilled, repeat checkups, treatment or pills or surgeries cost even more. So not only does it take away money, it takes away time that they could be using to make more money, especially in an area where unemployment is 14% and poverty at all ages is at 33%. There are people in these communities being constantly pushed down by factors out of their control.

That being said, mortality is factored in differently. The death of a person impacts the economy of the city whereas the hospital treatments and emergency visits are a drain on family or household wealth. While the overall economic impact is in the billions, it is important to note how the economic impact is separated, between city or household. Either way, the overall impacts are negative to the city of Oakland.

Furthermore, the BenMAP analysis did not exactly go as planned. I had intended for the BenMAP analysis to also give me valuations estimates based on valuation formula and data that I also input into BenMAP, but for some reason the values and estimations were always zero. In order to at least get some sort of estimate or valuation, I needed to utilize averages found in different studies and articles.

Despite these problems, the main point still stands, there is a large economic impact due to air pollution and air pollution related diseases. We can claim this as the incidence data was properly given from Alameda County, and the estimates were present.

### **Assembly Bill 617 and time to action**

Thankfully, action is being taken. The bill introduces a lot of ideas and contains a lot of moving parts but the core of what the bill does is that it directs the California Air Resources Board

and other air districts to act with and help communities that are disproportionately impacted by air pollution. As a result of how the bill functions, changes and actions will differ city to city, but the overarching ideal is the same: reduce air pollution and improve the health of communities. Furthermore, the local and state level air resources boards will be working with the communities. For Oakland, this includes trying to change where the trucks are parked when going to the port, look at where trash is being burned, and other air quality improvements. Unfortunately, as mentioned prior, the changes will take a few years as these are structural changes. They need to happen slowly and will take time, but the people of Oakland will continue to suffer from poor air quality conditions until then. Also, the air pollution situation in Oakland, as I am sure it is in other cities in California, has been a known problem for more than a decade. Although it is important to stay positive, it is going to be an agonizing process for the residents of Oakland.

### **Limitations and Future Directions**

My study population was only really limited to West Oakland, which comes with its own limitations. The results of my study cannot really be extrapolated to other cities, or even as Oakland as a whole. Results being the cost of air pollution in terms of health costs. Hospital price differs, pollution density differs, and population demographics also differ city by city. Furthermore, there are some limitations that are a result of BenMAP. One would be that ultimately BenMAP will provide an estimate. You can only do so much with an estimate, even if it is one that is well supported and made. Other limitations are that I rely on population and pollution data that are a few years old, so the numbers could be much different now.

One BenMAP analysis on the cost of the burden of air pollution is not the end all to problems that many communities face around the world. Looking at how people are suffering financially due to poor zoning laws or systematic racism is not the only way to tackle a problem like this. The study can include more on demographics in ways that show maybe specific populations are paying more than others. The study can also compare the costs to the average income or employment rates in the same communities. There is a wide variety that research like this can be used for and expanded on. Although the gap that I addressed was a narrow and niche one, it is still one that creates a lot of branches for interesting comparisons and insights within either the West Oakland community or any community that is analyzed in similar fashion.

## **Broader Implications**

When a lot of people think about climate change or pollution, they think of doomsday circumstances, and because they may not necessarily see the impacts in their daily lives, it is possible that they either don't believe in it, or they don't understand the gravity of the situation. However, the same cannot be said for people who either live in areas prone to natural disasters or next to point sources of pollution, like those in West Oakland. West Oakland is not a special situation. There are other places in the United States where communities are constantly exposed to detrimental air conditions, one example being Cancer Alley in Louisiana. It is always important to keep in mind that just because some people do not experience the reality of pollution and climate change, that the problem is not serious or that it does not exist. It is imperative that we work with these communities to make things better and spread the word that people are unjustly suffering today.

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