The Disproportionate Effect of Traffic Related Pollution on the Black Residents of Richmond Virginia

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

Do Americans have equal right to breathe clean air regardless of race and socioeconomic status? As the population of the United States grows and the number of vehicles on our cities' roadways increases, this question is becoming more and more relevant. In addition to this, a growing population demands an increased shipment of goods to meet the needs of the individual consumer and the economy at large. All of this vehicular traffic increases the amount of airborne Nitrogen Dioxide, NO2, and fine particulate matter, PM2.5, harmful pollutants in our cities ("Nitrogen Dioxide", 2020).

The question my STS paper intends to answer is if the Black population in Richmond Virginia is disproportionately exposed to traffic related pollutants. Additionally, I intend to identify contributing factors and potential solutions to this issue by employing Actor Network Theory (ANT).

The following section will explain the methodology and framework used for the analysis of my STS question. The section after this will go in to detail on the effect NO2 and PM2.5 have on the respiratory system, emission sources and the racial biases related to pollutant exposure, and the responsibility of government to regulate emissions. Next is a section giving historical context on major roadway construction through Richmond and how this affected historically Black neighborhoods in the city. Following this will be a section explaining the ANT analysis of the sociotechnical system dictating emission and exposure in the city. The next section conducts the actual analysis of the question and identifies the correlation between race and traffic related pollutant exposure. Finally, before concluding the paper identifies possible solutions through emission control and progressive legislation.

Methodology and Framework

I used a historical methodology for the analysis of Richmond Virginia. To examine the relationship between racial demographics and traffic related emission exposure in the city, I researched historic neighborhood demographics and road construction history. Additionally, I synthesized conclusions using previous research investigating how non-white communities are disproportionately exposed to traffic related pollution in cities, modern racial majority maps of neighborhoods, maps of traffic density through the city, and designated trucking routes throughout the city. To better understand the interplay between all relevant actors I employed the Actor Network Theory (ANT) framework (Latour, 2005). This framework focuses on identifying all actors, both human and nonhuman, in the system, connecting the relationships between them, and identifying concepts that may influence them. The following section discusses the harmful effects of prolonged NO2 and PM2.5 exposure.

Identifying the Problem

Traffic Related Pollutants in the Body

Research examining the long-term impact on lung health in individuals who are chronically exposed to the traffic related pollutants has recently begun to emerge. These are individuals who are dealing with long term exposure because their socioeconomic status dictates that they live in areas next to higher emission sources. Nicole Kravitz-Wirtz and collaborators found in their study on air pollution exposure, poverty, and childhood asthma development that individuals who live in these neighborhoods, and more specifically in close proximity to high traffic roadways, are at a significantly higher risk of developing asthma and respiratory system damage. Furthermore, this effect is more prevalent in children, "[f]indings suggest that early-life exposures to nitrogen dioxide (NO2), a marker of traffic-related pollution, and fine particulate matter (PM2.5), a mixture of industrial and other pollutants, are positively associated with subsequent childhood asthma diagnosis" (Kravitz-Wirtz et al, 2018, para. 1). Additionally, a study done by Sandrah Eckel and collaborators on the relationship between air pollution and lung cancer survival have linked NO2 exposure to shorter survival time in lung cancer patients as well as patients with other chronic diseases (Eckel et al, 2016). The American Lung Association warns that "Nitrogen dioxide causes a range of harmful effects on the lungs, including: Increased inflammation of the airways; Worsened cough and wheezing; Reduced lung function; Increased asthma attacks; and Greater likelihood of emergency department and hospital admissions." ("Nitrogen Dioxide", 2020). Furthermore, PM2.5 has been proven to have similar effects on the respiratory system including: decreased lung function, irregular heartbeat and higher heart attack

risk, and premature death in lung and heart disease patients ("Health and Environmental Effects of Particulate Matter (PM)", 2022). This in combination with NO2 is a dangerous mix with serious potential causing health problems. The following section will draw the correlation between race and pollutant exposure.

Exposure Sources and Racial Biases

After establishing the harmful health effects cause by traffic related pollutants, it's necessary to understand who is at the largest risk and why. Many of the same studies listed before also found correlations linking Black and Latino populations to higher levels of exposure. Why is this the case? This is due to the fact that, "Cars, trucks, and buses are the largest sources of emissions [for NO2], followed by power plants, diesel-powered heavy construction equipment and other movable engines, and industrial boilers." ("Nitrogen Dioxide", 2020). As it stands, non-white communities are significantly more exposed to this pollutant than predominantly White communities as a result of major emission sources being more likely to be located in close proximity to non-white communities (Kravitz-Wirtz et al, 2016). Additionally, a better understanding of how NO2 moves in the atmosphere provides more context for just how localized the exposure can be. A study conducted in 2003 looked at a highly trafficked interstate in Montreal Canada. The goal of the study was to determine how far from the emission source could significant levels of NO2 be detected. The maximum distance that the molecule was detected was 1.3km with concentrations decreasing significantly with distance from the road (Gilbert et al, 2003). Although the dispersal of traffic related pollutants is highly complex and dependent on multiple factors, clearly neighborhoods within this distance to major roadways are

at a significantly higher risk than neighborhoods outside this distance. The next section will describe what responsibility government has to protect its citizens from pollution.

Responsibility of Government

In September of 2022, the UN released a resolution that "everyone on the planet has a right to a healthy environment, including clean air, water, and a stable climate", establishing clean air as a basic human right ("Un declares healthy environment – including Clean Air – a human right", 2022). In the United States, the Clean Air Act, last amended in 1990, established maximum allowable concentrations of NO2 as a primary pollutant (meaning a pollutant that is directly emitted and not produced through chemical reactions in the atmosphere) at 100ppb (100 parts of NO2 present in 1 billion parts of atmospheric air on a volumetric basis). The concentration value present in any given city is calculated by taking the average of the daily maximum concentration over the course of three years. (Environmental Protection Agency, 2022). However, NO2 is a short-lived pollutant with a lifetime of only 1-hour, meaning concentrations are highly localized to their emission source. Data taken in 2009 found that some areas of LA experienced maximum NO2 concentrations of 160ppb (Gilbert et al, 2003). The Kravitz-Wirtz study on childhood asthma development concluded this: "Notably, however, existing research has increasingly found health risks associated with levels of NO_2 well below the EPA annual standard, suggesting that this standard may be insufficient to protect children's health." (Kravitz-Wirtz et al, 2018, para. 16). Clearly current emission standards are not sufficient to protect citizens of our large urban cities. They were simply not designed to consider communities that are exposed to higher levels of NO2 because of their close proximity to

emission sources. The next section walks through the history of roadway construction in Richmond and what neighborhoods were most effected.

Historical Context in Richmond

I-95, I-64, and Downtown Expressway Construction

In the mid-20th century, the growing population of Richmond and increasing demand for efficient vehicular travel through the city necessitated the construction of the first major roadways through the area. Construction of the Richmond-Petersburg turnpike, which would later become I-95, finished in July 1958. Subsequently, I-64 was completed a decade later, in 1968. In the late 60s, the Downtown Expressway project began acquiring properties for the construction of the road, "There were over 700 residential dwelling units relocated from the path of the expressway, mainly in the Randolph, Sydney and Oregon Hill neighborhoods" ("Richmond Interstates and Expressways", 2009) These are all historically Black neighborhoods in the city. Facing challenges with residential buy-ups for the project, the local city council voted to give the developers eminent domain over homes in the path of the newly constructed roadway if a settlement could not be negotiated. This means they had the right to force residents to accept compensation for the acquisition of their homes. Would a buy up of this magnitude and with eminent domain have taken place if the location of the expressway had bisected predominantly White neighborhoods? The developers took consideration to limit the amount of restructuring by imposing a major roadway in a downtown area. To do this the developers depressed the roadway into the ground, allowing for many bridges to easily cross the expressway. However, the

developers did not take the same consideration to mitigate the emission of NO2 and PM2.5 into the surrounding community. The result of the city's neglect to build a modern road system that equally impacts neighborhoods regardless of socioeconomic status is reflected in the demographics surrounding these roadways today. This will be discussed in further detail in the following sections.

ANT Analysis

Key Actors

For the analysis of the disenfranchised communities and roadway structure in Richmond Virginia, the ANT visualization focuses on identifying the largest actors and establishing their connection to the Black population, mostly in the Northeast, East, and South of the city. The most important of these actors is of course the disenfranchised communities living in close proximity to the roadways. Next are the state and local governmental bodies who pass legislation dictating when and where the roadways will be built. Connected to these governmental bodies is the Environmental Protection Agency (EPA), who is responsible for establishing regulatory legislation to limit emissions. For the ANT analysis, these are considered the most powerful human actors in the system. Also included in the analysis are a number of non-human actors. The most influential of these as follows: the detrimental health effects felt by the disenfranchised communities, political mistrust of state and local government, aversion to roadway proximity, and regulatory emission standards. Drawing connections between the human and non-human actors in the system gives insight into the power structure of the system and how these actors interact. The last part of the ANT analysis are the potential solutions to mitigate the

disproportionate pollutant exposure in the city. The connections between these solutions and the actors give insight into how the solutions can be enacted, who can enact them, and who they effect. The following section will examine the power structure of the system and detail the interplay between the actors.

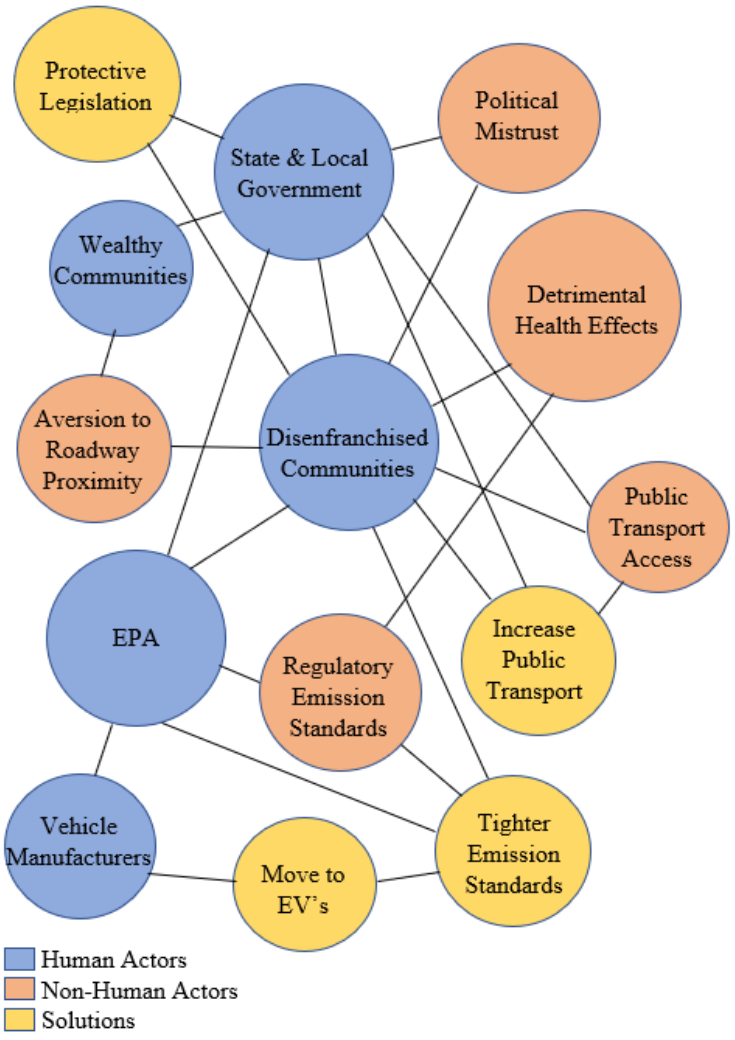

Figure 1: Actor Network Theory Web Graphic

Graphic Analysis

The web graphic establishes that the detriment to the disenfranchised communities' health is overwhelmingly caused by the actions of the state and local government. ANT analysis

also allows for insight into why this is the case. The local government is influenced heavily by the wealthy communities in the city. This is the case because these communities are also likely to hold much more political power to discourage the construction of interstates and highways through their neighborhoods, especially at the time of construction from the 50s-70s. Furthermore, the residential acquisition of these properties would have been more expensive and was likely to receive more backlash. Another factor is limited public transport. A possible solution to reducing the amount of vehicular traffic and in turn traffic emissions would be to establish an extensive public transport system that would discourage individual vehicular travel. The EPA also contributes to the detriment of the Black community in Richmond. As discussed previously, the emissions regulations established in the 1990 Clean Air Act are not sufficiently tight enough to actually protect individuals living in areas of high concentration. Should the EPA reevaluate their regulations of NO2 and PM2.5, they could help reduce the detrimental health effects caused by the emission. Additionally, ANT makes the point that the group that is inflicting the most harm also holds the most power over the entire system. This unbalanced power structure could potentially be mitigated by the solutions included in the graphic. The next section analyses the correlation between race and pollutant exposure in Richmond.

Correlation in Richmond

Traffic Related Pollutants and Communities of Color

As stated previously, recent research has proved the correlation between traffic related pollutants and communities of color. Overwhelmingly, these studies found that communities of color do indeed face health risks from NO2 and PM2.5 exposure and on average are exposed to much higher levels than White communities. An excerpt from the 2016 Kravitz-Wirtz study elaborates on why:

> "Second, and relatedly, sociopolitical explanations imply that industry and government seek the path of least resistance when siting hazardous waste and polluting industrial facilities and major roadways. Thus, neighborhoods with abundant resources and political clout, which also tend to house predominantly White individuals, tend to be actively avoided, whereas disenfranchised neighborhoods, in which people of color disproportionately reside, are sought out as easier targets because they tend to have fewer resources and are usually underrepresented among the decision-makers in industry and government." (Kravitz-Wirtz, 2016, para. 15)

With this in mind, the next section of the paper will focus on examining how this correlation plays out with racial minorities in Richmond VA, specifically the Black population which makes up almost 30% of the population of the city. ("Race, diversity, and ethnicity in Richmond, VA").

Comparing High Traffic Areas and Racial Majority Mapping

Now having examined the correlation between racial minorities and elevated exposure to traffic related pollution as well as the historical context in Richmond, an analysis of present-day Richmond is possible. Currently no NO2 and PM2.5 mapping on a scale sensitive enough to reflect neighborhood scale spatial variability is publicly available for Richmond. However, having established the fact that vehicular traffic is the greatest emission source, the highest concentrations of the pollutants are extremely localized (to within about a kilometer), we can directly correlate high traffic road proximity to high exposure. From this correlation, relevant conclusions about present day Richmond can now be drawn using racial majority mapping and traffic related data.

Figure 2: Racial Majority with Traffic Density Mapping[1]

[1] Richmond Interstates and Expressways, 2009; Virginia Traffic Volume Map, 2020

Pictured above is a racial majority map of Richmond city overlaid with a map depicting the traffic density of the roads. The areas in green are neighborhoods with a majority of Black citizens and in blue are neighborhoods with a majority of White citizens. The roads highlighted in purple are the highest trafficked, with the bold purple roads having over 50,000 vehicles a day ("Richmond Interstates and Expressways", 2009). A clear trend can be observed of the highest trafficked roads bisecting majority Black neighborhoods. In an independent analysis, I found that 59.04% of the highest trafficked roads bisected areas of the city with a majority of Black residents. The table below walks through how this percentage was calculated.

Road	Total Length (miles)	Length Bisecting Majority Black Neighborhoods (miles)	Percent of Length Bisecting Majority Black Neighborhoods
I-95	11.2	7.44	66.43%
I-64	10.6	6.82	64.34%
I-195	6.73	0.80	11.89%
Chippenham Pkwy	6.83	5.84	85.51%
Combined	35.4	20.9	**59.04%**

Table 1: Calculation for % of Highest Traffic Roadways that Bisect Majority Black Neighborhoods in Richmond Virginia

The total length column refers to the length of the road pictured in Figure 1 that is driven by more than 50,000 vehicles per day. The length bisecting majority Black neighborhoods column refers to the length of the road that is bounded by majority Black neighborhoods. Recall that this demographic makes up only 30% of the total population of the city. The fact that a minority demographic constitutes the majority of the individuals with the highest pollutant exposure reflects the injustice of pollutant exposure faced by non-white communities. This finding is also in line with the trend that was found in the previously referenced studies.

As previously mentioned, the bold purple roads receive the heaviest traffic. These roads are I-95, running north/south through downtown, I-64 running east/west through downtown, I-195 running southwest/northeast to the west of downtown, and the Chippenham Parkway running north/south also west of downtown. All of these roads, with the exception of some of I-95, bisect areas of the city predominantly populated with Black citizens. Additionally, many other high traffic density roads cutting through and circumnavigating the city bisect these areas.

Figure 3: Racial Majority with VDOT Designated Trucking Mapping[2]

This trend is further made apparent when examining the racial majority map of Richmond city overlaid with a map of VDOT designated trucking routes. Blue denotes a nationally designated shipping route and red indicates a state designated shipping route. Of vehicular related emissions, large diesel semitrucks are the greatest pollutants of NO2 and PM2.5 ("Nitrogen Dioxide", 2020). As can be seen above, the majority of the routes bisect predominantly Black areas of the city. Based on what has been learned about environmental racism through traffic pollutants, how these pollutants travel, and the figures above, I conclude that the Black

[2] Richmond Interstates and Expressways, 2009; VDOT Designated Truck Routes and Length Restrictions, 2020

population in Richmond is exposed to higher levels of NO2 and PM2.5 than the White population in the city. The following section will explore the possible solutions to this issue.

Proposed Mitigation

Recall the ANT analysis from earlier. The goal of the analysis was to identify the most important actors in the system, human and non-human. From this, connections can be made between the actors with the intent of identifying sources of influence for each actor and establishing a visual for the power structure of the system. It was found that overwhelmingly, state and local government in addition to the EPA are the biggest contributors to the issue and have the most potential to implement change that would improve the situation. The following sections will explore the potential solutions that could be implemented by these actors, as identified through the ANT analysis.

Reducing Emission

Richmond is not at all unique in this issue of traffic emissions related environmental racism. As previously discussed, this is a trend that is present in many major cities across the US. This is a factor of the sociopolitical strategy to construct polluting infrastructure in locations that will lead to the least amount of backlash. Tragically this often winds up being in disenfranchised neighborhoods with few resources to combat this. Surely this practice does not hold true to the UN's statement that clean air should be a basic human right. This raises the question; how might this issue be solved? The first and most obvious answer is to reduce the amount of NO2 and

PM2.5 emitted by vehicles. There are a number of ways to achieve this. First is of course is for individuals to move to electric vehicles as they do not directly emit pollutants as they drive. However, this would create demand for more the generation of electricity and care would need to be taken to ensure the emissions and infrastructure from power plants are not disproportionately harming disenfranchised communities. Additionally, creating public transport that would remove the need for individual vehicular travel could help solve the issue. Again, care would need to be taken to ensure that this new infrastructure would not impose health risks and would be equally accessible to all citizens throughout the city.

Progressive Legislation

Another route to solving this issue would be to implement new legislation with the intent to mitigate the disproportionate exposure that the Black community in Richmond faces. In 2020 Virginia legislature passed the Virginia Environmental Justice Act (VEJA). This act calls for "the fair treatment and meaningful involvement of every person, regardless of race, color, national origin, income, faith, or disability, regarding the development, implementation, or enforcement of any environmental law, regulation, or policy" (Duimstra, 2021, para. 3). This establishes the legal right for equal access to environmental factors regardless of race in Virginia. However, with the findings of this paper as evidence, despite this law environmental racism still exists in Virginia. Just last year, in 2022, congress passed the Environmental Justice for All Act. This act was proposed with the goal of mitigating the effect government and industry have had on environmental injustice and improve conditions for disenfranchised communities in the

future. One of the important most components of the act is summarized below:

> One key component of the EJ for All Act is the strengthening of the National Environmental Policy Act (NEPA), a law that has provided the foundation for public participation in federal government actions since it was enacted in 1970. Section 14 of the EJ for All Act will help fully realize NEPA's potential to be a powerful tool for environmental justice, by requiring federal agencies to provide early and meaningful community involvement opportunities for proposed projects that may affect an environmental justice community. (Lam, 2022, para. 4)

In addition to this, the EJ for All Act also requires policy makers to consider historical context for communities when implementing potentially polluting infrastructure. Also enacted in 2022 is New York's Green Act. This act establishes the right to "clean air and water, and to a healthful environment" and establishes legal grounds for individuals to sue if these rights are not met (Owens-Chaplin, 2022). Moving forward, should the city of Richmond properly apply the VEJA in addition to the EJ for All Act and adopt similar legislation to New York's Green Act, the victims of environmental injustice in the city should have more political power to express their desire for clean air and equality.

Assumptions and Limitations

Before concluding with my findings, it is important to state the assumptions of the analysis and possible limitations of research. For the scope of this paper living in direct proximity to a highly trafficked roadway is considered exposure. This assumption is valid considering the 2003 study in Montreal detected significant amounts of NO2 up to 1.3km away from the target roadway. This study found that concentrations ranged from 11.9ppb (at 1.3km from source) to 29.3ppb (right next to the source). The roadway used in the study sees an average of 185,000 vehicles per day (Gilbert, 2003). For context, I-64 north of downtown in Richmond sees about 150,000 vehicles per day (Virginia Traffic Volume Map, 2020). In the asthma development study, it was found that their sample was exposed to a mean NO2 concentration of 12.80ppb. Children exposed to concentrations more than 21.31ppb had a significantly greater chance of developing asthma at a factor of 1.26 (Kravitz-Wirtz 2018). This paper assumes a similar NO2 concentration is present along the highest traffic roadways in Richmond given the similar traffic volumes. Therefore, it is likely that concentrations exceeding 21.31ppb are present in direct proximity to sections of roads that see the heaviest traffic through the city.

An additional assumption is made that the traffic in both Montreal and Richmond have similar emission amounts on a per vehicle basis. However, emission standards have changed since 2003. This in addition with the rise in use of hybrid and electric vehicles may alter the amount of emissions on a per vehicle basis. This paper is limited in the fact that NO2 and PM2.5 emission, dispersion, and exposure is dependent on many variables including wind, temperature, roadway separation infrastructure, population density, etc. Without access to raw NO2 and

PM2.5 concentration data in Richmond, synthesizing conclusions based on the findings of previous research gives us the best understanding of pollutant exposure in the city.

Conclusions

The focus of this paper has been on answering the question: Is the Black population in Richmond Virginia is disproportionately exposed to traffic related pollutants? Based on the assumptions listed in the previous section, I find that:

1. The Black population of Richmond Virginia is disproportionately exposed to traffic related pollutants.
2. These citizens may have an elevated health risk due to traffic related pollution.

To do this, I first covered the harmful effects of NO2 and PM2.5 on the respiratory system. Then, I established the correlation between racial minorities and disproportionate exposure to traffic related pollutants by looking at previous studies. Following this, I reviewed the historical context for the construction of the interstates and other major highways through the city. From here enough background was established to perform an Actor Network Theory analysis on the city. This laid out the power structure of the system and identified key actors to target for the mitigation of disproportionate pollutant exposure.

Through ANT analysis, I identified a number of solutions as well as the actors who have the potential to implement them. After building a solid understanding of the system, I examined racial majority maps along with traffic density mapping and designated trucking routes and it was found that the Black minority in Richmond makes up 59.04% of communities that are bisected by major roadways. Following this, again from ANT analysis, I discussed possible

solutions and how they could be implemented. Going back to the question at the center of this paper, this paper found that the Black population is indeed disproportionately exposed to NO2 and PM2.5. Through conscious effort by cities to provide equal access to infrastructure to all its residents, working with the EPA and major vehicle manufacturers to reduce pollution in cities, and progressive legislation to protect citizens from environmental injustice, this disproportionate exposure can be mitigated.

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