Environmental Injustice in Massachusetts: The COVID-19 Pandemic, Air Pollution, and Other Correlating Factors

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by

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Environmental Injustice: The COVID-19 Pandemic, Air Pollution, and Other Correlating Factors in Massachusetts

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The Coronavirus pandemic has cast a new light on the intersection of environmental justice and public health, as communities of color and low-income communities have experienced greater rates of infection and mortality due to the Covid-19 pandemic. These inequalities can be attributed to a multitude of injustices. I investigate the impact that air pollution has had on COVID-19 incidence within Massachusetts, while also investigating other possible correlating factors. I use a regression model to consider the impact of air pollution, population density, race, income, age, and education on COVID-19 positivity rates in Massachusetts. In this study, I found that air pollution, population density, and the percentage of Hispanic population in a given community were all statistically significant in a linear regression model. Further research would be needed to investigate whether the coefficient on Hispanic population is conclusive. It is possible that the significant coefficient is picking up variables that are not included in this regression, namely the percentage of essential workers or access to healthcare.

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TABLE OF CONTENTS

INTRODUCTION

Dr. Anthony Fauci, director of the U.S. National Institute of Allergy and Infectious Diseases, and the chief medical advisory to the President, said of the COVID-19 pandemic that it is shining “a very bright light on some of the real weaknesses and foibles in our society (Lahut 2020).” Though these issues have been prevalent in our societies for much if not all of American history, they are only now gaining traction and recognition within the academic sphere. In the past three decades, there has been an extensive expansion of the field of Environmental Justice, founded on the works of Robert Bullard. More recently, there has been extensive research conducted on the disproportionate impact that air pollution has on communities of color and individuals within low income communities.

This study specifically focuses on the variables that are associated with higher incidence rates of COVID-19 specifically in the state of Massachusetts. In this study, I found that air pollution, population density, and the percentage of Hispanic population in a given community were all statistically significant in a linear regression model.

THE ENVIRONMENTAL JUSTICE MOVEMENT

In 1992, staff writers from *The National Law Journal* wrote about environmental inequalities that had been 'uncovered' in recent years, saying

> "There is a racial divide in the way the U.S. government cleans up toxic waste sites and punishes polluters. White communities see faster action, better results and stiffer penalties than communities where blacks, Hispanics and other minorities live. This unequal protection often occurs whether the community is wealthy or poor" (Bullard, Robert., Mohai, Paul., Saha, Robin., Wright 2008).

This inequity in government attention, environmental protection, and social recognition define the issues within Environmental justice.

In 1979, environmental justice was thrust into the public eye at a national scale for the first time over a dispute over the siting of a landfill for polychlorinated biphenyls (PCBs) in Warren County, North Carolina. PCBs are a group of man-made carbon organic-based chemicals that belong to the family of chemicals known as chlorinated hydrocarbons (EPA 2020). PCBs are no longer commercially produced in the United States due to the health risks they pose, but many are still present in commercial products that were produced before 1979 (EPA 2020). Exposure to PCBs has been shown to cause a variety of negative effects on the immune system, nervous system, endocrine system, and others (EPA 2020).

Warren County is a predominantly Black community. The location of this landfill in this area without the consent of the residents led to an eruption of protests in the area, which subsequently led to greater than 500 arrests (Bullard, Warren, and Johnson 2005). Though the protesters were unsuccessful in convincing the federal government to relocate the landfill, their unity of action put environmental justice issues on the map. Warren County environmental justice leaders and their allies worked for decades to ensure that federal officials followed through on their promises to clean up the mess they had created (Bullard, Warren, and Johnson 2005). However, the decades long delay allowed the harmful pollutant to leach into the groundwater, endangering the community (Bullard, Robert., Mohai, Paul., Saha, Robin., Wright 2008). In 2001, two decades after the initial outcry, the EPA finally began detoxification the landfill site (Bullard, Warren, and Johnson 2005).

Following the Warren County protests, the U.S. General Accounting Office was forced to open an investigation into these injustices. The study, entitled *Siting of Hazardous Waste Landfills and Their Correlation with Racial and Economic Status of Surrounding Communities*, concluded that 3 of the 4 off-site commercial hazardous waste landfills in the U.S. EPA's Region 4 (eight southern states in the south) were located in largely African American communities, though African Americans only made up 20 percent of the region's population (Bullard, Warren, and Johnson 2005).

In 1987, a landmark report was released on the issue of environmental justice. The United Church of Christ published *Toxic Wastes and Race in the United States,* the first study to correlate hazardous waste and demographics. *Toxic Wastes and Race in the United States* found race to be more important than socioeconomic status in predicting the location of the nation's commercial hazardous waste facilities (Bullard, Robert., Mohai, Paul., Saha, Robin., Wright 2008). This finding was corroborated in 1998 by Dr. Liam Downey (Downey 1998). This national study was incredibly valuable because it changed the way people looked at environmental justice issues. Prior to the study, environmental justice issues seemed to be individual, localized, and often isolated community-based struggles. *Toxic Wastes and Race in the United States* showed that these issues were part of a larger trend of injustice spanning the United States and beyond.

Environmental justice addresses the disproportionate siting of environmental hazards such as hazardous materials, pollution, and environmental degradation. The siting of these hazards has had a disproportionate effect on low-income and predominantly Black and Hispanic communities. One of the seminal texts of the Environmental Justice movement is *Dumping in Dixie*, written in 1990 by Dr. Robert Bullard, the leading scholar of the environmental justice movement. This important book differentiates between environmentalism and environmental justice, where environmentalism consists of white-middle class individuals, while Environmental Justice is a movement of people of color and the poor (Bullard 2000).

In 1998, approximately 23,000 facilities reported the release of 7.3 billion pounds of pollutants into the air, water, and underground areas (Faber and Krieg 2002). These toxic pollutants pose a significant risk to individuals who breathe them in, drink them, or live in close proximity to them for long periods of time. A 2005 study found that African Americans are 79 percent more likely than whites to live in a neighborhood where industrial pollution poses the greatest health danger (Bullard, Robert., Mohai, Paul., Saha, Robin., Wright 2008). In 2001, industry in the US generated approximately 41 million tons of hazardous wastes (Bullard, Robert., Mohai, Paul., Saha, Robin., Wright 2008). Numerous studies have found that this hazardous waste is disproportionately sited in poor and non-white communities (Bullard 2000; Bullard, Robert., Mohai, Paul., Saha, Robin., Wright 2008; Bullard, Warren, and Johnson 2005).

In *Dumping in Dixie,* Bullard describes extensive disparities between low-income and higher-income communities in their abilities to adapt to or escape environmental injustice. He addresses, for example, that higher-income communities being able to buy an air conditioning unit or bottled water. Poor and minority communities saw environmentalism as elitist oppression. Bullard also recognized that there has been and is economic and political mistrust from the Black community towards traditional environmentalists, who were largely constructed of white males from affluent communities (Bullard 2000). This same point was also argued by Professor Rob Nixon in *Slow Violence and Environmentalism of the Poor*, another staple in environmental justice literature (Nixon 2011).

This pattern of inequality in exposure and ability to adapt is a global issue. In *Slow Violence and Environmentalism of the Poor*, Nixon (2011) investigates and addresses the difficult truth that traditional environmentalists in rich countries advocating against dumps and toxins have led to governments and companies to moving these aesthetically undesirable and potentially hazardous things to poorer countries and communities (Nixon 2011). Nixon cites a chilling quote by Lawrence Summers, the then President of the World Bank.

> "I think the economic logic behind dumping a load of toxic waste in the lowest-wage country is impeccable and we should face up to that. . . . I've always thought that countries in Africa are vastly under polluted; their air quality is probably vastly inefficiently low compared to Los Angeles. . . . Just between you and me, shouldn't the World Bank be encouraging more migration of the dirty industries to the Least Developed Countries?" (Nixon 2011)

This quote reflects a deeply disturbing and pervasive trend in capitalist societies in which marginalized populations and even countries disproportionately bear the burden of environmental injustice. Injustices towards poor and marginalized societies who have very little to no financial or political power are readily ignored by many societies in our world. Nixon focuses on the struggles of the global South, but he addresses the economic motivations for these injustices and the reasons that it is so hard for vulnerable communities to fight back. These patterns are seen both on the global scale and within the United States.

A critical debate in the field of environmental justice is whether race or income was the better predictor of environmental injustice in any given area. The issue was and is especially difficult to investigate and solve because of the notable correlation between income and race in the United States. An important work at the end of the century that essentially ended this debate was *Environmental Justice: Is Race or Income a Better Predictor?* (Downey 1998). In this work, Downey follows the toxic release inventory in Michigan and addresses different definitions of environmental justice, explaining that some more old-fashion approaches focus on *intentional acts* of environmental justice. These so-called *intentional* acts see environmental justice issues as individuals knowingly and intentionally placing environmental hazards near the homes of communities that are largely people of color or impoverished, or as it is in most cases, both. In contrast, Downey proposes that a more modern way to think of environmental justice issues is through the frame of *institutionalized* issues. Regardless of the intent of these city planners or other individuals, these hazards *are* disproportionately harming people of color. He argues that this injustice comes about through already institutionalized injustices including, but not limited to redlining, a process by which money lenders would refuse to make loans to people living within a certain 'redlined' area. Redlining caused communities of color to be sectioned off from society and decreased possibilities for economic mobility.

The environmental justice movement combines social justice issues with environmental issues, often drawing from either or both movements for support and recognition. Powerful civil rights activists in the 60's were often fighting for environmental justice issues, years before the language of the environmental justice was created. In 1968, Martin Luther King Jr. went to Memphis on what turned out to be an early environmental justice mission, where Black garbage workers were striking for equal pay and safer working conditions. Black workers were not only being paid less than their white counterparts, they were also being forced to work more dangerous and dirtier tasks (Bullard, Robert., Mohai, Paul., Saha, Robin., Wright 2008).

The environmental justice movement and the civil rights movement have been extremely connected since the advent of the environmental justice movement. In *Power, Justice, and the Environment: A Critical Appraisal of the Environmental Justice Movement*, Dr. Byron Anderson compares the two. In his interpretation, the environmental justice movement has included more activists and fewer students than the civil rights movement, and it has included all people of color instead of just Black people (Anderson 2006). The environmental justice movement has also been more focused on bottom up activism and community research, and has had very limited success on the national scale or in court, in comparison to the civil rights movement. The limited legal success of environmental justice movement has been connected to the successes of the civil rights movement, notably the Title VI of the Civil Rights Act of 1964 (Bullard, Warren, and Johnson 2005).

In *Dumping in Dixie,* Bullard (2000) argues that the Environmental Justice movement is a fusion of the Civil Rights movement and the Environmental movement. This work addresses the conversation about race versus class in environmental justice. Another important phrase in the field of environmental justice is *environmental racism*, the description of environmental injustice that occurs specifically towards people of color, both in practice and in policy.

Poor Blacks do not have the opportunity to "vote with their feet," they cannot move away from areas that they have issues with or that are bringing them harm. Bullard describes discrimination in housing: government supporting the white movement into the suburbs while at the same time breaking apart inner city communities with highways and interstates. The work addresses how land use and zoning policies perpetuate environmental racism. Bullard was one of the first and certainly the most notable scholar to explicitly link environmental risks to health outcomes within Black communities (Bullard, Warren, and Johnson 2005).

Another landmark for the environmental justice movement was the First National People of Color Environmental Leadership Summit, held in 1991. Some argue that the summit is the single most important event in the environmental justice movement's history (Bullard, Warren, and Johnson 2005). The summit gave a voice to the movement, and broadened the movement's scope to include public health issues, worker safety, land-use, transportation, housing, resource allocation, and community empowerment, alongside the previously discussed impacts of hazardous waste (Bullard, Warren, and Johnson 2005). *Dumping in Dixie* was the only book on the subject of environmental justice at the time of the First National People of Color Environmental Leadership Summit in 1991.

In response to the growing public concern about environmental justice issues in the United States, the EPA created the Environmental Equity Workgroup in 1990, which became the Office of Environmental Equity in 1992 (Anderson 2006). A grant program and the National Environmental Justice Advisory Council were created (Anderson 2006). President Bill Clinton issued Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* on February 11^{th}. 1994 in an attempt to combat environmental injustice within existing legislation (Bullard, Warren, and Johnson 2005). Executive Order 12898 acts to reinforce Title VI of the Civil Rights Act of 1964, which prohibits discriminatory practices in programs receiving federal funds (Bullard, Warren, and Johnson 2005). It mandates that health impacts are investigated and the disproportionate effects on people of low income or minority status are assessed. However, many have argued that the federal government have not followed through on what was promised in the Executive Order (Bullard, Warren, and Johnson 2005).

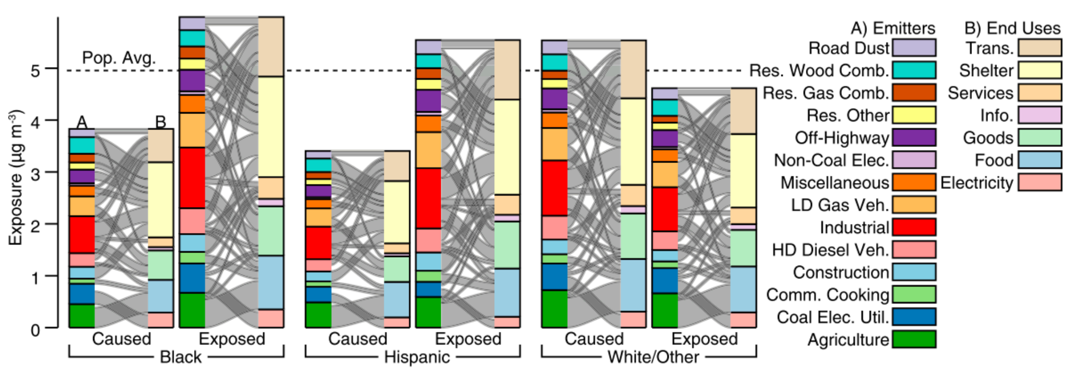
Environmental injustices are often overlooked or blatantly ignored in the United States and around the world. One reason for this might relate to Robert Nixon's concept of slow violence. In *Slow Violence and the Environmentalism of the Poor,* Robert Nixon argues that there is a temporal element to violence: slow violence which occurs over decades does not attract the same media attention as rapid acts of violence or disaster (Nixon 2011). Slow violence is often seen in the United States in the unjust siting of communities near Locally Unwanted Land Uses (LULUs). LULUs are plots of land that create negative externalities on those who live within the proximity, often including emitting industries or hazardous waste sites.

AIR POLLUTION

Air pollution from LULUs has been an important issue within the environmental justice movement. Air pollution is a general term used to describe pollutants in the air, which can include Nitrogen Oxides, most commonly Nitrogen Dioxide or Nitric Oxide (NOx) and particulate matter (PM), which is a mixture of solid and liquid particles that are suspended in the air. Particulate matter can be emitted 1naturally from events such as wildfires or volcanoes. In the context of environmental justice issues, however, particulate matter is typically emitted by industry or transportation. Particulate matter is distinguished by the size of the suspended particles, most commonly discussed at 2.5 or 10 μm in diameter, referred to as PM2.5 or PM10, respectively. PM2.5 is discussed more consistently in literature due to the fact that the smaller particles can get deep into lungs and pose a greater risk to health. The presence of PM2.5 in an area has been notably linked to many negative health effects, including respiratory and cardiovascular diseases, as well as premature death (Mikati et al. 2018). PM2.5 is estimated to be responsible for 63 percent of all deaths from environmental causes (Pinto de Moura and Reichmuth 2019).

Mikati et al. (2018) found striking evidence of trends of environmental injustice in the United States. They found that individuals in poverty resided in an area in which the PM in the area was 1.35 times higher than individuals who are not in poverty, individuals that considered themselves non-white lived in an area where PM that was 1.28x higher than white individuals, and individuals who were Black lived in areas where the PM was on average 1.54x higher than white individuals. This inequality is not only unjust from a public health standpoint. The individuals who are most likely to be exposed to these toxic air pollutants are not the same individuals who are benefiting from the goods and services that are produced in the process in which the PM is released. A study done in the Proceedings of the National Academy of Sciences of the United States of America explored "pollution inequity", and found that PM2.5 exposure is disproportionately caused by consumption of goods and services by the non-Hispanic white majority, while the pollution is disproportionately experienced by Black and Hispanic minorities (Tessum et al. 2019). Figure 1 shows the disparity graphically.

Figure 1*: Average PM2.5 Exposure Experienced and Caused by Racial Ethno-Groups.*



Source: (Tessum et al. 2019)

As can be seen in Figure 1, Black and Hispanic individuals are more likely than whites to be exposed to harmful pollutants and less likely than whites to be causing the production.

Figure 1 also shows that there are many different *types* of emitters, ranging from the transportation industry to power plants. In 2019, a study conducted by the Union of Concerned Scientists specifically focused on the Northeast and Mid-Atlantic United States found that there is inequitable exposure to Air Pollution from vehicles (Pinto de Moura and Reichmuth 2019). They found that Latinx residents are exposed to 26 percent more air pollution than their white counterparts and African Americans are exposed to 34 percent more (Pinto de Moura and Reichmuth 2019).

ENVIRONMENTAL INJUSTICE IN MASSACHUSETTS

Environmental justice issues are prevalent all over the United States, but for the purpose of this literature I will dive deeper into environmental justice issues in Massachusetts, specifically tied to air pollution. Using 1990 U.S. Census data and 2000 Department of Environmental Protection data, Faber and Krieg (2002) found that low income communities in Massachusetts face unequal exposure to ecological hazards (Faber and Krieg 2002). Specifically, they found that people of color are 47 percent more likely to live near hazardous sites than white people (Faber and Krieg 2002). They also found that there is unequal exposure to landfills, fly ash, and hazardous air pollutants (HAPs) (Faber and Krieg 2002).

Exposure to air pollution, as mentioned previously, can have drastic health effects on individuals. The effects can be both acute and chronic, ranging from eye irritation, nausea, difficulty breathing, asthma, or even death (Faber and Krieg 2002). In the long term, exposure to hazardous air pollutants can cause damage to the respiratory or nervous systems, birth defects, neurological disorders, and cancer (Faber and Krieg 2002). In Massachusetts specifically, poor air quality poses a very serious threat to public health. According to an investigation done through the U.S. EPA Cumulative Exposure Projects (CEP), every single county in Massachusetts has levels of key airborne toxic chemicals that exceed health-based state levels (Faber and Krieg 2002). There have been multiple studies performed in the past few decades in Massachusetts that corroborate the findings that have been previously discussed: environmental hazards and pollutants are disproportionately situated and affecting communities of color and impoverished communities (Faber and Krieg 2002; Bullard 2000; Downey 1998). Massachusetts keeps track of large emitters via the Massachusetts Toxics Use Reduction Act (TURA) program, which began in 1998. TURA is an act that requires companies with a considerable usage of toxic chemicals to annually report the types of toxic chemicals that they use, conduct toxics use reduction planning every two years, and pay a fee (Faber and Krieg 2002). They must report the quantity of toxic chemicals it uses annually only if it uses, manufactures, or produces 10,000 pounds of the chemical or more. In Massachusetts, the largest contributors to onsite releasing of pollutants into the environment are the electric, gas, and sanitary services sectors (Faber and Krieg 2002).

Communities with lower incomes, specifically, those at the lowest bracket with a median household income of $0 to $29,999, have a disproportionately high average number of polluting TURA facilities in their area (Table 1). They also face a considerably higher average TURA emissions per town, and have the highest level of TURA emissions per square mile. Communities with a median household income of less than $30,000 have on average 6.3 TURA facilities per town, 932,910 total pounds of chemical emissions released into the environment per town, and 73,061 total pounds of chemical emissions per square mile of town space during the years 1990-1998.

Table 1: *Class-based Disparities in the Exposure Rate to TURA Industrial Facilities (1990-1998)*

Median household income (1990 U.S. Census category)	Number of towns (% of all towns)	Average number of TURA facilities per town	Average number of TURA facilities per square mile	Average total TURA chemical emissions (lb) per town	Average total TURA chemical emissions (lb) per square mile
$0 to $29,999 (low)	50 (13.6)	6.3	0.49	932,910	73,061
$30,000 to $39,999 (med–low)	137 (37.2)	2.7	0.21	603,905	55,524
$40,000 to $49,999 (med–high)	114 (31.0)	1.8	0.13	161,028	10,937
$50,000 or more (high)	67 (18.2)	2.2	0.12	248,478	12,502

Source: Faber and Krieg 2002

Similarly shocking statistics were found by the 2002 study that points out the racial disparities in the exposure rate to these emitting facilities (Table 2) (Faber and Krieg 2002). Communities of color are disproportionately overburdened. These findings show that communities where people of color compose 25 percent of more of the population average 8.8

TURA facilities and 1.1 TURA facilities per square mile, a staggering statistic when compared to an average of just 2 facilities and .12 facilities per square miles in communities where people of color compose less than 5 percent of the population. High-minority communities average over 4 times as many TURA industrial facilities and over 9 times as many TURA industrial facilities per square miles as do low-minority communities in Massachusetts (Faber and Krieg 2002).

Table 2: *Racially Based Disparities in the Exposure Rate to TURA Industrial Facilities (1990-1998)*

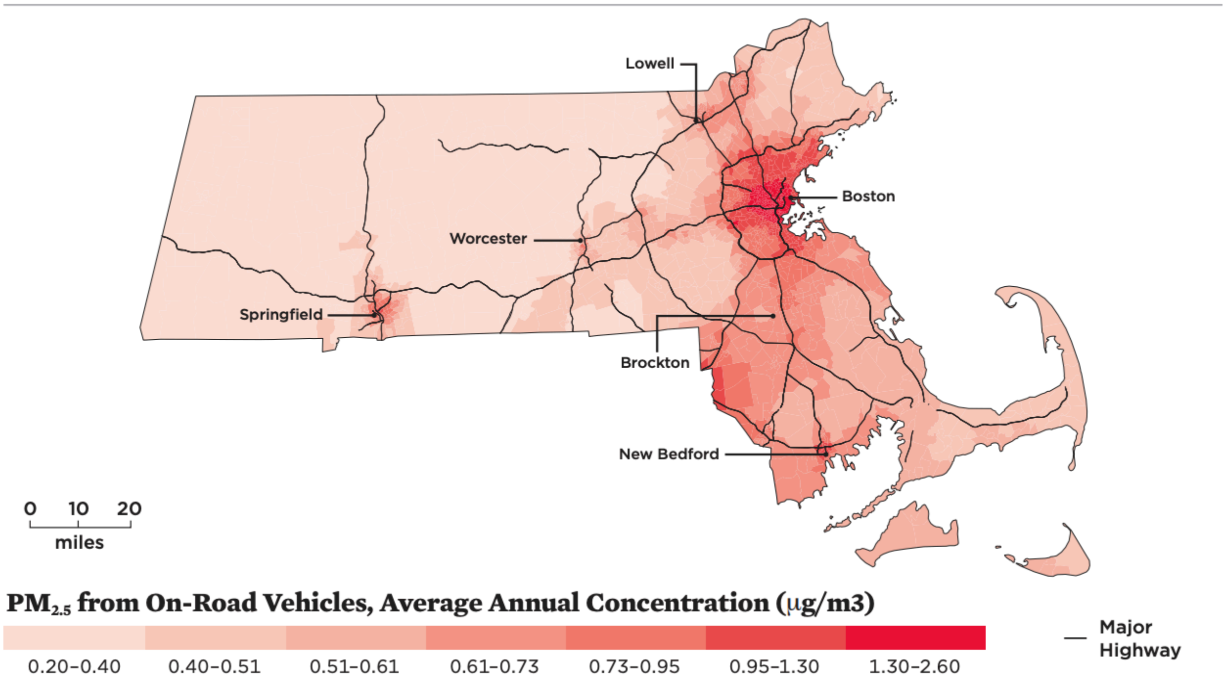
Non-White population (1990 U.S. Census category)	Number of town (% of all towns)	Average number of TURA facilities per town	Average number of TURA facilities per square mile	Average total TURA chemical emissions (lb) per town	Average total TURA chemical emissions (lb) per square mile
Less than 5% (low)	299 (81.3)	2.0	0.12	343,579	22,735
5–14.99% (low–moderate)	49 (13.3)	5.4	0.40	796,689	86,014
15–24.99% (moderate–high)	9 (2.4)	7.4	0.75	1,216,369	123,770
25% or more (high)	11 (3.0)	8.8	1.1	1,061,041	110,718

Source: Faber and Krieg 2002

This inequality in pollution in Massachusetts is not limited to emissions from emitting facilities. A 2019 study on emissions from vehicles found that Asian American, African American, and Latinx residents of Mass are exposed to higher PM2.5 pollution from vehicles than other residents (Pinto de Moura and Reichmuth 2019). Specifically, Latinx Residents and African American residents are exposed to 26 percent and 34 percent, respectively, more air pollution than their white counterparts (Pinto de Moura and Reichmuth 2019**).** The authors point to decades of Massachusetts state and local decisions for the cause of these inequalities. More specifically, decisions about where to place highways, where to invest in public transportation, and where to build affordable housing all contribute to a system plagued by environmental injustice. Notably, they mention that "in many cases, local, state, and federal transportation policies have left communities of color with inadequate access to public transportation, divided by highways, and breathing air polluted by congesting highways serving suburban commuters" (Pinto de Moura and Reichmuth 2019). Figure 2 shows the concentration of PM2.5 from On-

Road Vehicles in Massachusetts. Understandably, areas with high amounts of vehicle traffic and population density such as Boston have much higher concentrations of PM2.5.

Figure 2: *High Variation in Exposure to PM2.5 Pollution from On-Road Vehicles in Massachusetts*



Source: US Census Bureau 2018, EPA 2014 (Faber and Krieg 2002)

These findings were calculated using ground level pollution exposure for each census tract combined with information from population and demographic data. Figure 2 does not contain data on other modes of transportation, such as planes, marine vessels, or trains. Springfield, Massachusetts has the nation's highest rate of asthma-related emergency room visits, with transportation emissions more than 43 percent higher than the state average (Pinto de Moura and Reichmuth 2019). The study also found that PM2.5 exposure from vehicles is much higher for people of color than for white individuals (Pinto de Moura and Reichmuth 2019).

THE COVID-19 PANDEMIC

The recent COVID-19 pandemic has helped further expose the disproportionate impact of air pollution on people of color. COVID-19 exacerbates this inequality. The Centers for Disease Control and Prevention released a list of risk factors for severe COVID-19 which includes diabetes, heart disease, and chronic airway diseases, such as asthma, lung cancer, and chronic obstructive pulmonary disease, all of which overlap with the list of diseases that are known to be worsened by chronic exposure to air pollution (Brandt, Beck, and Mersha 2020).

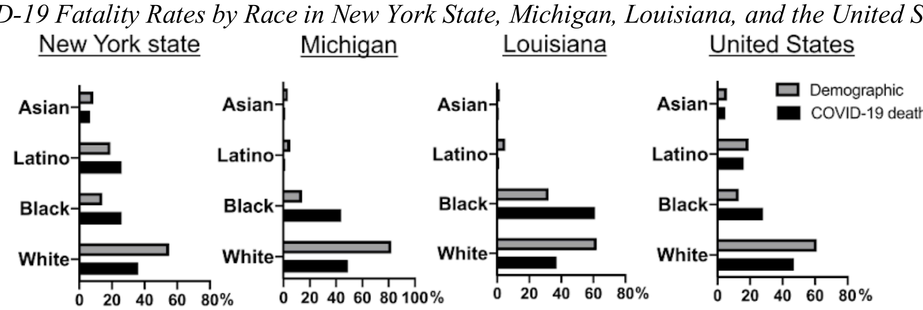
Research on the COVID-19 pandemic and its disproportionate impact is still in its infancy. One way to more intimately understand the current disproportionate effects of the coronavirus pandemic is to look at the trends from the 2003 SARS epidemic in China. Both COVID-19 and SARS are infectious diseases with similar symptoms, caused by a coronavirus. Investigation into the 2003 SARS outbreak in China showed a positive association between acute and chronic pollution measures and SARS case-fatality rates (Cui et al. 2003). The work used publicly accessible data on SARS morbidity and mortality and cumulative air pollution data using the air pollution index (API) (Cui et al. 2003). The API included concentrations of particulate matter, sulfur dioxide, nitrogen dioxide, carbon monoxide, and ground-level ozone. The study found that SARS patients from regions with high APIs were twice as likely to die from SARS as compared to those individuals from regions with low APIs (Cui et al. 2003).

Many studies have reported that the COVID-19 pandemic has been showing patterns similar to the 2003 SARS outbreak, with high correlation between air pollution and COVID-19 mortality/morbidity. Researchers from the Harvard T.H. Chan School of Public Health focused on the link between COVID-19 mortality and air pollution. They found that an increase of only 1 microgram/meter cubed in PM2.5 is associated with a 15 percent increase in COVID-19 mortality rate, at a 95 percent confidence interval (Wu, Nethery, Benjamin, et al. 2020). Their results were statistically significant and robust. However, given that research into the COVID-19 pandemic is still is still in its early stages, it is important to note that a study conducted in June of 2020 through the National Bureau of Economic Research did not find a significant correlation between air pollution and COVID-19 death rates (Knittel and Ozaltun 2020). Their research replicated the work done by Wu et al., 2020, and found that the addition of variables such as climate, transport data, and additional health data made the coefficient for air pollution insignificant (Knittel and Ozaltun 2020). In their analysis, Knittel and Ozaltun suggest that there is not a direct causal link between COVID-19 deaths and air pollution given the same data used in Wu et al., 2020.

It has been documented over the past year that the COVID-19 pandemic has disproportionately affected people of color (Brandt, Beck, and Mersha 2020; Wu, Nethery, Benjamin, et al. 2020; Rossen et al. 2020). One recent study found that the population of African Americans within a population correlates with higher death rates in the area (Knittel and Ozaltun 2020). Another study corroborating this finding within the COVID-19 pandemic found high correlations between COVID-19 deaths and *all* minority groups, with especially robust correlations for Black and First Nations populations (McLaren 2020).

COVID-19 death rates appear to be higher in higher populated areas. For example, cities like New York City and Detroit have been hit at a much higher rate than the rest of their respective states (Brandt, Beck, and Mersha 2020). However, population density does not explain why the Bronx has twice the number of COVID-19 fatalities than Manhattan, pointing to socioeconomic and racial disparities between the areas (Brandt, Beck, and Mersha 2020). In fact, data has continuously looked to racial and socioeconomic disparities for causing unprecedented levels of Coronavirus mortalities and morbidities in certain areas. In the early stages of the outbreak in Michigan, 33 percent of COVID-19 cases and 44 percent of deaths were experienced by Blacks even though they represent a meager 14 percent of the state population (Brandt, Beck, and Mersha 2020). Similar patterns of disproportionate effects have been found among other communities of color, specifically Hispanic communities (Bixler et al. 2020; Rossen et al. 2020; Wan 2020). Disproportionate effects on people of color have also been reported in studies throughout the United States, specifically in Chicago and throughout Louisiana (Brandt, Beck, and Mersha 2020). These trends are also reflected in fatality rates in New York State, Michigan, Louisiana, and the United States when compared to the general population (Figure 3).

Figure 3: *COVID-19 Fatality Rates by Race in New York State, Michigan, Louisiana, and the United States*

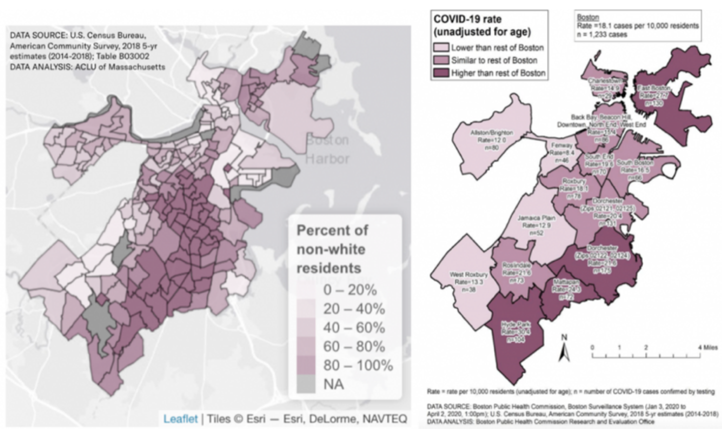


Source: Brandt, Beck, and Mersha 2020

There are many factors that may contribute to these disheartening patterns, some of which stem from the systemic oppression of people of color. In the United States, Blacks are more likely to experience adverse housing conditions, crowded living environments, diminished access to things like health care and healthy food options, use of public transportations, and, as previously discussed, an increased exposure to air pollution (Brandt, Beck, and Mersha 2020). Black individuals and people of color in general are also more likely to be essential workers, employees whose work was deemed essential for the continuity of critical functions within the United States, such as the distribution of food or medicine (Gavin 2020). Essential workers have been put at a considerable risk during the COVID-19 pandemic, being forced to continue work in person at a much greater risk of contracting the disease. Cardiovascular diseases and diabetes also disproportionately affect racial minorities (Brandt, Beck, and Mersha 2020).

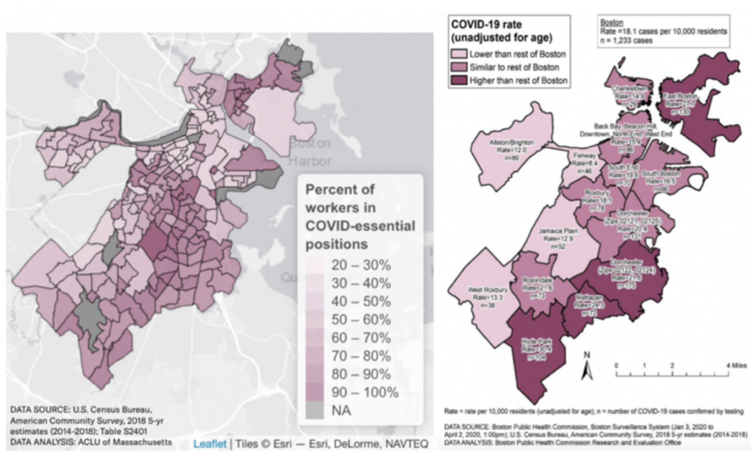
In Massachusetts specifically, data from the Boston Public Health Commission and the 2018 American Community Survey revealed that COVID-essential workers and non-white residents were concentrated in the very same neighborhoods (Figures 4a and 4b) and experienced the highest rates of COVID-19 (Chambers 2020).

Figure 4a: *COVID-19 Rate and Percent of Non-White Residents in Boston, MA*



Source: Chambers 2020

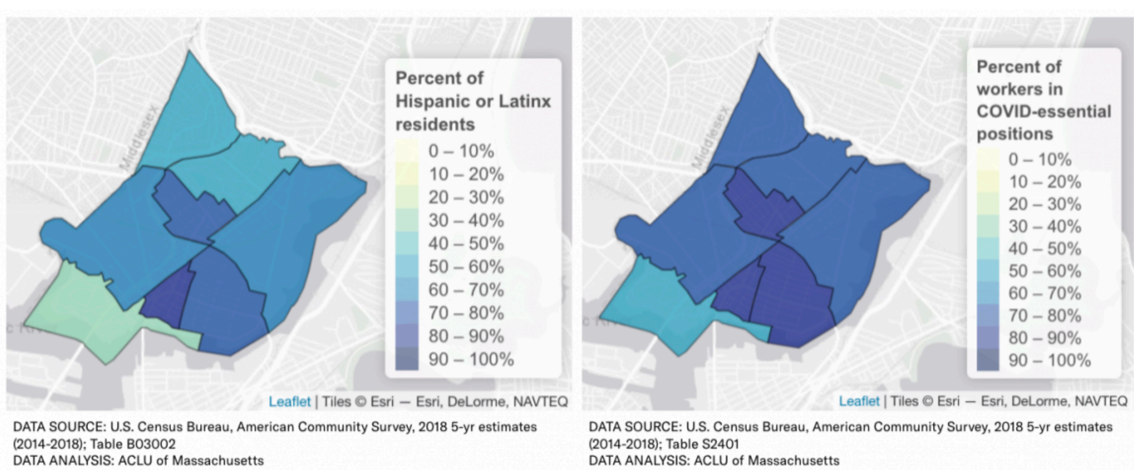
Figure 4b: *COVID-19 Rate and Percent of COVID-Essential Positions*



Source: Chambers 2020

Figure 4a and 4b show the dramatic differences in COVID-19 rate between areas that have similar population densities and are relatively close in proximity. For example, East Boston has been much more heavily affected by COVID-19 than South Boston. The area of East Boston is especially notable because East Boston contains Chelsea, a town with the highest levels of COVID-19 in all of Massachusetts (Congi 2020). More specifically, over 70% of Chelsea's population is classified as essential workers and the town has a COVID-19 positivity rate of 79 per 10,000 residents, which is four times higher than in nearby Boston (Chambers 2020). It is also a town that has extremely high levels of Hispanic or Latinx residents (Congi 2020). These overlapping risk factors have both contributed to their high levels of the virus (Figure 5). A large portion of the population are immigrants, many of whom lack legal status, leaving them economically vulnerable and without access to health care and other public support networks (García 2020).

Figure 5: *Chelsea, Massachusetts: Percent of Hispanic or Latinx Residents and Percent of Essential Workers in*



Source: Chambers 2020

Chelsea is an unique area within Boston not just because of its high COVID rates, but also because it has notably high air pollution rates. It contains the New England Produce Center, a transportation hub with an enormous constant rate of emissions (Greenberg 2020). Approximately 85,000 vehicles, not including ships and planes, pass under and over the Chelsea Tobin Bridge on a daily basis (Congi 2020).

METHODS

In order to investigate the relationship between COVID-19 and air pollution in Massachusetts, I ran a regression with air pollution, average education, race, income, and population density as the independent variables, and COVID-19 positivity rate per 100,000 people as the independent variable. . Given recent research done on the correlations between air pollution, COVID-19, and race in the United States (Knittel and Ozaltun 2020; Wu, Nethery, Sabath, et al. 2020; McLaren 2020), I hypothesized that there would be statistically significant coefficients for *AvgPM2.5, PercentHispanic,* and *PercentBlack.*

The COVID-19 data that I used in my regression was sourced from the public data available through the Massachusetts Government COVID-19 Response Recording (Mass.gov 2020). The Commonwealth of Massachusetts has been releasing weekly data on COVID-19 positivity rates since January 1^{st}, 2020. For my analysis, I used data from January 1^{st} to May 20^{th}, 2021 because it encompassed the first wave of COVID-19 in the United States (Rossen et al. 2020). It is a time period that captures the onset of the pandemic in the United States and is representative of the early period of quarantine. Importantly, it is also a time over which data has been solidly collected and analyzed. I used cumulative data rather than weekly data, in an effort to represent the general trends in each area as opposed to possible weekly anomalies that might be seen with particular spikes in certain areas in any given time.

The COVID-19 data was presented town-by-town, while the data for most of the other variables was by zip code. In order to perform a more accurate analysis, I broke the data up by zip code. The COVID-19 data on the zip code scales were more precise than the other units of data on the town-by-town scale.

The data for COVID-19 might be mis-measured in my regression for a variety of reasons. One important variation might include the variance around testing in different towns in Massachusetts, especially in this earlier portion of the pandemic. However, there should be some semblance of uniformity in the testing strategies as the Massachusetts government facilitated the testing in much of the state. Furthermore, the date range that I chose to focus on may also contribute to uncertainty in my regression. COVID-19 testing in the beginning of the pandemic was a time that was full of uncertainty and inconsistency in things like testing, health care, and public opinion on the virus. It is likely that there would be many different variables that I did not account for in my regression that could lead to a skewing of the COVID-19 rates. These potential confounding variables would likely include, but are not limited to, percentage of essential workers, access to adequate healthcare, type of residency, and access to technology (the need to travel for work). Data for these potential variables was difficult to gain access to within the time frame of this study. I attempted to account for these shortcomings in using proxy variables such as income and education level in an attempt to pick up inequities that are not so easily defined in data[1].

The first independent variable in my regression is Air Pollution. The variable Air Pollution contains data for PM2.5, fine particulate matter. For the purpose of my research, I used PM2.5 as a proxy for all air pollution as it is the type of pollutant that is most often referenced with relation to air pollution (Zhu 2020, Zhang, 2017, Rosofski, 2019). My PM2.5 data was acquired from the Center for Research on Environmental and Social Stressors in Housing Across the Life Course (CRESSH) and the Boston University School of Public Health, with the help of

[1] Another potential error surrounds the unreliability and uncertainty of tests. I recognize that the COVID-19 rates that I have in my datasets likely do not represent the actual COVID-19 rate within the entire Massachusetts population, given that there were likely individuals who did not get tested or individuals who received false positives. However, measurement error in the dependent variable would only affect the regression if the errors were systematic, which is unlikely (i.e. testing were incorrect only in lower-income places)

Dr. Jonathan Levy, Dr. Patricia Fabian, and Ms. Fei Carnes. It is average data for the year of 2015. There could be potential for error in this data analysis given that it is data from 5 years ago. I am operating under the assumption that this data is representative of current levels of air pollution in the areas, given that 5 years is a relatively small time for large-scale infrastructure changes in a given area, specifically the situation of PM2.5 emitting industrial sectors or major roadways. There have been reports that air pollution in specific areas, specifically air pollution due to travel, has decreased due to the COVID-19 pandemic, however the decrease had been minimal(Sommer, Lauren, Hersher, Rebecca, Jingnan, Huo, Benincasa 2020). Furthermore, a decrease in air pollutants would not affect the health implications associated with air pollution as it is long-term exposure to pollutants that impacts health.

Similar to the COVID-19 data, the air pollution data was given on the town level, so in order to combine the data with the other variables I had to break the variables out into zip codes. This could reduce precision in the analysis as the air pollution and COVID-19 levels are both averages in areas while the other data varies by zip code. The data is the same that is being used in the current Health Effects Across the Life Course (HEAL) study at CRESSH. The data is the annual average concentration of PM2.5 per cubic meter of volume for the year of 2015. Though this data shows the air pollution levels five years prior to the COVID-19 pandemic, the data is still valuable and relevant because the health effects that result from exposure to PM2.5 are typically associated with long-term exposure to the toxic pollutants (Berglind, 2017).

There are many variables that would be beneficial to my analysis that I was not able to find and use for my research, including: whether the individuals smoke, whether individuals have access to healthcare, the rate of obesity, and whether the individuals in a given area make healthy decisions. These factors have been shown to put people at a greater risk (Coccia 2020).

In order to account for some of these questions, I chose to use education as a proxy variable within my regression. The data for education is from the American Community Survey from the period of 2008 to 2013. This data provides a useful background in the general trends of education patterns of areas within the past 10 years. Education was used as a proxy for factors that might not be accounted for with race or income. It is not likely that education or lack thereof would lead to a direct influence in COVID-19 positivity rates, but education is highly correlated with these other factors that likely would.

Initially, I included both a variable for graduating high school and graduating college. The variable for high school graduation (*hsgrad*) described the percentage of individuals within a population that graduated from high school and or post high school education, including both trade schools and college education. The college graduation variable (*collegegrad*) describes the percentage of individuals that graduated from high school and college within a population. However, after seeing my regression results early on in my research, I noticed that when both variables: *hsgrad* and *collegegrad* were used in the regression, neither were statistically significant, as there was overlap between the variables. The presence of both high school education and college education created too much of an overlap and decreased the significance of the resulting coefficients. After experimenting with these different variables and noting the implications of the significance levels, I determined that it would be better if I focused only on college education (*collegegrad*).

The next variables that are used in the analysis are related to race. This data was also from the time period of 2008-2013 from the American Community Survey, a demographics survey program conducted by the U.S. Census Bureau. Hispanic and Black populations have been noted to have suffered disproportionately due to the COVID-19 pandemic (Brandt, Beck, and Mersha 2020). Both of the variables, *percentblack* and *percenthispanic*, reflect the percentage of Black and Hispanic individuals in a given area, respectively.

Age, another vital variable, also influences the number of COVID-19 incidences in a given area (Ogen 2020; Glück 2020; Rossen et al. 2020). For this information, again I used data from the American Community Survey from 2008 to 2013. I combined the data for males over 65 and females over 65, creating the variable *over65*, which represents the percentage of individuals in a given area that are 65 years and older. To further investigate this phenomenon, I added the variable *agesquared*. I did this to capture what I suspected might be a nonlinear relationship between age and the Covid-19 rate. Adding *agesquared* and looking at the relationship as a quadratic would allow me to see if the nonlinear pattern was apparent and notable.

My final variable was population density. Population density is important when dealing with contagious diseases (Gavin 2020). The population density data was also found with the American Community Survey from 2008 to 2013. The data are population per square mile.

I used the software Stata to run the regression. I dropped all data points that had missing variables for COVID-19 rate and air pollution. The data points that were dropped were points where the data did not overlap. What I was left with was a dataset that included 379 distinct data points of towns and cities. Within my data, larger areas such as Boston and Worcester with multiple zip codes within their areas accounted for multiple different data points.

I had to destring all of the variables I was using, since they were entered as string variables within my program, or variables that included both numbers and words. I created a regression using these data points (Table 5). I also standardized the variables and created a regression with standardized variables (Table 6) , in order to reduce multicollinearity and make the data points easier to interpret.

During the process of my research, I recognized that it was possible that Chelsea may have skewed the data in the regression. Chelsea has the second highest concentration of Hispanic individuals in Massachusetts. In order to investigate this affect, I ran the regression without Chelsea, which decreased the Hispanic significance.

RESULTS

This investigation into COVID-19 incidence rates and other factors showed that PM2.5 (*AvgPM2.5*), the percentage of the population that had graduated from college (*collegegrad*), the percent of Hispanic individuals within a given population (*PercentHispanic*) and the population density of a given area (*PopDensity*) were statistically significant factors affecting the COVID-19 incidence rates in Massachusetts (Figure 5).

For every one unit increase per cubic meter of volume of PM2.5, the Covid rate increases by 390 per 100,000. It is important to note that the values for PM2.5 range from 5.64 to 9.18, with the majority of values lying between 6.00 and 7.00. The data for PM2.5 has a mean of 6.77 and a median of 6.72. A one percent increase in the percentage of the population who graduated from college leads to a decrease in covid rate of 21.6 per 100,000, and a 1 percent increase in percentage of Hispanic individuals in a population leads to an increase in covid rate by 13.5 per 100,000. Similarly, an increase in population density by 1 individual per square mile leads to an increase in Covid-19 rate of .0318 per 100,000.

Table 5: Regression Table

Covid Rate per 100,000	Coef.	Std. Error	t	P>|t|	95% Confidence Interval	
AvgPM2.5	390	73.8	5.29**	0.00**	245	535
CollegeGrad	-21.6	4.14	-5.22**	0.00**	-29.8	-13.6
PercentBlack	-9.78	3.72	-2.63	0.009	-17.1	-2.46
PercentHispanic	13.5	2.93	4.62**	0.00**	7.78	19.3
MedIncome	.00169	.00116	1.46	0.145	-.000586	.00397
MedianAge	-20.8	25.4	-0.82	0.415	-.00586	.00397
MedianAgeSquared	.251	.342	0.73	0.464	-.421	.923
PopDensity	.0318	.00529	6.01**	0.00**	.0214	.042
Constant	-1020	687	-1.49	0.138	-.2370	331

Source: American Community Survey 2013, CRESSH

The variable *PercentBlack* is surprisingly significant and negative. This does not fit with what I would have expected to see given nationwide evidence showing that Black communities are disproportionately affected by COVID-19 (Brandt, Beck, and Mersha 2020). This anomaly may be attributed to multicollinearities between *PercentBlack* and other variables within the regression, as variables such as *MedIncome, CollegeGrad,* and *AvgPM2.5.* This same anomaly may be affecting the coefficient for *PercentHispanic*.

In order to more easily understand the implications of these results, I standardized the data (Table 6). With the standardization, one standard deviation change in PM2.5 leads to an increase of the COVID-19 rate by 191 per 100,000; one standard deviation increase in the percentage of college graduates in area lead to a decrease in the COVID-19 rate by 185 per 100,00; one standard deviation increase in the percentage of the Hispanic population lead to an increase in the COVID-19 rate by 158 per 100,000; and one standard deviation increase in the population density of an area lead to an increase in the COVID-19 rate by 213 per 100,000.

Table 6: Standardized Regression Table

Covid Rate per 100,000	Coef.	Std. Error	t	P>|t|	95% Confidence Interval	
SDAvgPM2.5	191	36.2	5.29**	0.00**	120	262
SDCollegeGrad	-185	35.5	-5.22**	0.00**	-255	-116
SDPercentBlack	-95.4	36.3	-2.63	0.009	-167	-24.0
SDPercentHispanic	158	34.2	4.62**	0.00**	90.8	225
SDMedIncome	54.5	37.3	1.46	0.145	-18.8	128
SDMedianAge	-136	166	-0.82	0.415	-462	191
SDMedianAgeSquared	122	166	0.73	0.464	-205	449
SDPopDensity	213	35.5	6.01**	0.00**	144	283
Constant	965	31.6	30.56	0.00	903	1030

Source: American Community Survey 2013, CRESSH

Excluding Chelsea from the data did not significantly change the regression results, though it did increase the significance of PM2.5 and decrease the significance of the percent of the population that is Hispanic.

Table 7: Standardized Regression Table without Chelsea

Covid Rate per 100,000	Coef.	Std. Error	t	P>|t|	95% Confidence Interval	
SDAvgPM2.5	188	33.6	5.60**	0.00**	122	255
SDCollegeGrad	-170	33.1	-5.15**	0.00**	-236	-105
SDPercentBlack	-94.8	33.8	-2.81	0.005	-161	-28.4
SDPercentHispanic	108	32.5	3.34**	0.00**	44.5	172
SDMedIncome	35.5	34.8	1.02	0.308	-32.9	104
SDMedianAge	-76.6	154	-0.50	0.620	-381	227
SDMedianAgeSquared	46.9	155	0.30	0.763	-258	352
SDPopDensity	201	33.1	6.07**	0.00**	136	266
Constant	953	29.4	32.4	0.00	895	1010

Source: American Community Survey 2013, CRESSH

DISCUSSION

The results of this study show that air pollution is a significant factor influencing those who test positive for COVID-19 in Massachusetts, and likely the severity. Given recent research done on the correlations between air pollution, COVID-19, and race in the United States (Knittel and Ozaltun 2020; Wu, Nethery, Sabath, et al. 2020; McLaren 2020), I had hypothesized that there would be statistically significant coefficients for *AvgPM2.5, PercentHispanic,* and *PercentBlack.* Surprisingly, the coefficient for the *PercentBlack* variable was both statistically significant and negative, contradicting what we have seen in previous studies (Brandt, Beck, and Mersha 2020). This result was surprising and might be attributed to possible multicollinearities or omitted variables. Other possible limitations from this study includes the exclusion of the percentage of the community that is an essential worker, which, as addressed in the background, has been shown to be strongly correlated with a higher risk of contracting COVID-19. This variable was not included due to the lack of sufficient data available at the time of this study. Another important limitation to this study is that the COVID-19 data is that it used positivity rate, not the mortality rate. This data may reflect things like quantity of testing in an area as opposed to severity of the COVID-19 virus in an area. Positivity rate was used in this study as mortality rate data was not yet open to the public. However, it is still useful to provide insight into the general level of impact that COVID-19 has had on a given area.

It is important to add context to this data and to recognize that all of the COVID-19 cases recorded in this analysis took place in the final year of President Trump's presidency. President Trump notably rolled back environmental regulation in favor of industry. According to the *New York Times*, President Trump completed 28 rule reversals that allowed for air pollution and emissions to increase (Popovich, Nadja, Albek-Ripka, Livia, Pierre-Louis 2021). These included reversing Obama-era standards for passenger cars and trucks, withdrawing a Clinton-era rule that limited toxic emissions from major industrial polluters, and relaxing air pollution regulations for plants that burn waste coal for electricity (Popovich, Nadja, Albek-Ripka, Livia, Pierre-Louis 2021). Researchers at Carnegie Mellon University found that fine particulate pollution had increased by 5.5 percent on average across the United States between 2016 and 2018 (Popovich 2021). This increase is only partially linked to Trump's rollbacks, and might also be attributed to an increase in industry and roadway usage. However, these trends would not be captured in my analysis as the air pollution data that I use is from 2015.

This is an increasingly problematic statistic considering that air pollution levels had been decreasing steadily over the previous seven years (Popovich 2021). Massachusetts government data suggests that in general over the past 10 years, the annual PM2.5 levels have decreased by approximately 2 micrograms per cubic meter (DEP 2020). It is worth noting, however, that according to the EPA, PM2.5 levels dropped by 4 percent from 2017 to 2019 (US EPA 2020). The differences in reports of levels of pollution from differing sources is striking and might be an indication of potential biases within reporting agencies.

The nature of tackling a current important global issue like the COVID-19 pandemic is that there are innately things about the disease and its social, environmental, or political implications that we do not yet fully understand. However, it is important that we make note of the trends that we are currently witnessing and attempt to make sense of them as best as we can. Importantly, the COVID-19 pandemic significantly reduced levels of air pollution on a global scale. There were significantly fewer cars on the roads and planes in the air, especially in the first few months of the pandemic. This led to a reduction in the global levels of PM2.5 by 20-34 percent in the first few months of the pandemic (March and April 2020) as compared to the air pollution levels in 2019 (Kumari and Toshniwal 2020). However, it is likely that this decrease in pollutants is temporary, and that we will likely revert back to pre-COVID levels of pollution when we begin to fully reopen (Venter et al. 2020). Furthermore, the lockdown period did not eliminate emissions. Even though traffic from passenger cars decreased, trucks, factories, and power plants continued to pollute the air (Sommer, Lauren, Hersher, Rebecca, Jingnan, Huo, Benincasa 2020).

This study found that air pollution, population density, and the percent of the population that is Hispanic, and the percent of the population that has a college degree are all factors that are highly correlated with the COVID-19 positivity rate in a given area. The data shows a correlation between PM2.5 and COVID-19 incidence rate and does not find definitive evidence for PM2.5 leading directly to higher rates of COVID-19. In other words, my regression shows correlation, not causation. As referenced in the background if this thesis, there is an extensive amount of research that has been done suggesting that there is a causal relationship between air pollution and COVID-19, but this study does not conclusively prove any causal relationship.

The statically significant positive correlation between population density and COVID-19 is expected as areas that are more densely populated innately allow for a greater spreading of diseases. More people in any given area increases the chances that you will contract COVID-19 (Gavin 2020). The statistically significant positive correlation between the percentage of the population that is Hispanic and COVID-19 positivity rates is also expected as it is likely a reflection of lack of access to health care or populations that are essential workers. The legal status of recent immigrants in the area would also affect access to social programs or health care that would increase resources and decrease the risk of being exposed to COVID-19 (Russell 2020; Rossen et al. 2020; Su et al. 2011). Finally, *CollegeGrad* is statistically significant and negative, which is likely a reflection of essential workers without a college degree being exposed to COVID-19 at a greater rate (Chambers 2020).

Given the correlation between PM2.5 levels and COVID-19 positivity rates, it is important to investigate potential policies that would help to decrease the disproportionate effects of air pollution. The primary policy change that I would advocate for within this study is to increase the regulations and enforcement on pollution. On the state level, the Massachusetts Clean Air Act has standards that are currently greater than the current federal regulations (DEP 2020), but we must have stricter auditing and constant regulation, ensuring that there are limited violations. Following pressure from a local grassroots organization in Chelsea, Greenroots, the Massachusetts Department of Environmental Protection has recently installed 9 air quality monitoring stations within Chelsea to allow for more accurate tracking of particulate matter (DeCosta-Klipa 2020).

On the federal level, we must increase overall regulations on emissions from both vehicles and industry, and decrease the overall risk of exposure to air pollution. The Executive Order on Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis was presented on January 20th, 2021 by President Biden and his team. In Section iv. of this briefing, President Biden has shown that there is a new national goal of reducing air pollutants, advocating for new emissions standards for hazardous air pollutants in industry, increased transparency in the benefit and cost analyses in the Clean Air Act, and a strengthening of overall regulatory actions (White House Briefing Room 2021).The Biden Administration has already revoked a Trump era action to prioritize economic considerations over air quality standards (Milman, Oliver, Chang 2021).

With the new perspective on environmental issues in the current administration, there is optimism that there will be more regulation passed on a federal scale. Some have argued that the current EPA standards do not do an adequate job at assessing pollutant hot spots in any given area as the standards apply to large geographical areas (Kahmi 2018). It would be beneficial for the EPA or an independent agency to do a study investigating the effectiveness of their current testing processes. More research is needed at the town-by-town scale to address the inequalities individual communities face with respect to air pollution.

CONCLUSIONS AND FURTHER RESEARCH

The COVID-19 pandemic has shed more light on existing inequalities throughout the United States and the world. It is important that we recognize these inequalities, enhance existing environmental regulations, and continue extensive research on this subject to work towards a more equitable and healthier world.

Of course, there is room for error within this regression analysis. There may be inaccuracies linked to omitted variables. Specifically, one variable whose absence might bias the results of this regression is the population of essential workers in a given area. Essential workers are at a much higher risk of contracting COVID-19 due to their frequent exposure to individuals outside of their immediate sphere. Research has found that the Boston neighborhoods with the highest incidences of COVID-19 are the neighborhoods with the highest populations of essential workers (Stening 2020). Data on essential workers at the state level was not available at the time of this study but further investigation should be done on this subject. More research should be done to investigate what makes populations more vulnerable to COVID-19: whether it is employment, race, or exposure to air pollution. More investigation into the vulnerabilities within our communities would help to uncover what interventions would be most beneficial.

It would also be beneficial to revisit this work while investigating mortality rates, instead of positivity rates, as that would look more at the impact that long-term exposure to air pollution has on the severity of COVID-19, as opposed to simply the quantity of the population that tested positive. At the time of this study, there was substantially greater and more easily accessible data on positivity rates.

This study found a strong correlation between COVID-19 positivity rates and air pollution. While these results are not necessarily conclusive given some unexplainable inconsistencies, notably the coefficient on the variable *PercentBlack*, it does in general support the findings of other recent studies (Rossen et al. 2020; Wu, Nethery, Sabath, et al. 2020; Zhu et al. 2020; Greenberg 2020).

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