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Evaluation of Toxic Release Inventory Facilities in Metropolitan Atlanta: Census Tract Demographics, Facility Distribution, Air Toxic Emissions and Regulation

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Evaluation of Toxic Release Inventory Facilities in Metropolitan Atlanta: Census tract demographics, facility distribution, air toxic emissions and regulation

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Evaluation of Toxic Release Inventory Facilities in Metropolitan Atlanta: Census tract demographics, facility distribution, air toxic emissions and regulation

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Table of Contents

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Ryan W. Johnson, 5/15/2014

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ABSTRACT

Background and Purpose

Low socioeconomic status (SES) populations as well as minorities are often exposed to a disproportionate number of hazardous chemical including hydrogen fluoride, benzene and formaldehyde (Bullard, 2008). The sources of these hazards may include noxious land uses such as incinerators and landfills, Superfund sites, Toxic Release Inventory (TRI) facilities, sewer and water treatment plants, and other locally unwanted land uses (Choi, Shim, Kaye, & Ryan, 2006). The disproportionate burden often results in increased exposure to harmful environmental conditions for affected communities (Wilson et al., 2014). The objectives of this study are to evaluate the relevance of demographic characteristics to (1) TRI facility location, (2) TRI chemical emissions, and (3) incidence and resolution of facility complaints.

Methods

The study area is the Atlanta Metropolitan Statistical Area (MSA), designated by the United States Office of Management and Budget is comprised of 20 counties. Multivariate logistic regression was used to assess the relative importance of race and socioeconomic variables in predicting whether a TRI facility was located in a census tract. We applied multiple regression models to examine the association between amount of air toxics released from TRI facilities in the census tract (dependent variable), the number of emissions from TRI facilities in the census tract and the amount of chemicals released per emission and socio-demographic variables at the census tract level. Additionally, multivariate ordinal logistic regression was used to evaluate the association between the number of complaints to toxic chemicals and time to resolution of complaints and the covariates (SES and race/ethnicity) at the census tract level.

Results

In multivariate models the odds ratio for the presence of a TRI facility is 0.89 ($p=0.002$) for each 1% increase of females with a college degree and 2.4 ($p < 0.0001$) for each 1% increase of household with an income of $22,000-$55,000. In census tracts that have TRI facilities, there are 4.7% more minority residents. The estimated difference in the amount of chemicals emitted per release associated with a 1% difference in percent of population of females with a college degree was -18.53 pounds ($\beta=-0.1853$, $P= 0.009$). Those census tracts that had multiple complaints to air toxics had 4.3% fewer minority residents then the census tracts that had no complaints ($\beta=0.006$, $P= 0.009$). Furthermore, complaints to toxic chemicals were resolved at a lower rate in census tracts with large Hispanic populations.

Discussion and Conclusion

We found evidence of racial and socio-demographic disparities in the burden of TRI facilities and chemical emissions in the Atlanta MSA. We observed a trend for toxic chemicals emitted suggesting that more blacks and Hispanics were burdened by and potentially exposed to TRI facilities than were Whites. There was only one predictor, percentage of females with a college degree, where we observed an inverse and statistically significant association with the amount of chemical emissions in pounds. We also found evidence that of potential differences in regulation processes of TRI facilities. Overall, results indicate that race/ethnicity and socioeconomic composition play a role in TRI facility siting and TRI facility emissions indicating burden disparities for low-SES populations as well as non-Whites in the Atlanta MSA. These results are similar to results presented in the environmental justice literature.

List of Tables

List of Figures

I. Introduction

1.1 Background

History of Environmental Justice

According to the Environmental Protection Agency (EPA), "Environmental Justice (EJ) is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies (US EPA, n.d.)." Environmental justice emerged as a movement in the United States in the early 1980s, in response to the historical patterns of exploitation, commodification, and devaluation of place, space and people, within minority and disadvantaged communities(S. M. Wilson et al., 2012). The environmental justice movement is a social movement that includes researchers and activists advocating for the health of communities affected by disparities in burden, exposure, and environmental health hazards. In 1987, the first comprehensive national report on EJ, *Toxic Waste and Race in America*, empirically demonstrated that many minority communities and disadvantaged populations are disproportionately burdened by environmental hazards and unhealthy land uses (Chakraborty, 2004). This report demonstrated these burden disparities heavily influence health outcomes and disparities in the United States. Since the 1987 report, researchers in environmental justice science have shown that these disparities continue to exist.

Exposure Disparities

Low socioeconomic status (SES) populations as well as minorities are often exposed to a disproportionate number of hazardous chemical including hydrogen fluoride, benzene and formaldehyde (Robert D. Bullard, 2008). The sources of these hazards may include noxious land uses such as incinerators and landfills, Superfund sites, Toxic Release Inventory (TRI) facilities, sewer and water treatment plants, and other locally unwanted land uses (Choi, Shim, Kaye, & Ryan, 2006). The disproportionate burden often results in increased exposure to harmful environmental conditions for affected communities. Exposure disparities are founded upon social factors such as socioeconomic status, racism, and inequities in zoning and planning (Robert D. Bullard, 2008). Evidence has shown that constant exposure to these harmful conditions results in negative health outcomes, stressed communities, and reduction in quality of life and neighborhood sustainability (Atari, Luginaah, Xu, & Fung, 2008).

Health Effects of Toxic Air Pollutants

Most air toxic chemicals are derived from anthropogenic sources, including factories, refineries and power plants (Adamkiewicz et al., 2010). Toxic air pollutants are those that are known or suspected to serious health effects. EPA designates 187 air pollutants as harmful to the environment and also to public health (US EPA, n.d.). Examples of these pollutants include benzene, which is found in gasoline; hydrogen fluoride, emitted from coal burning power plants; and methylene chloride, which is used as a solvent and paint stripper by a number of industries(US EPA, n.d.). There is a wide array of health effects of these chemicals. Including cancer development, respiratory ailments, as well as neurological, reproductive, and developmental issues(Choi et al., 2006). In addition to exposure through inhalation, some toxic air pollutants such as mercury can deposit onto soils or surface waters, where they can be taken up by plants and ingested by animals and are eventually magnified up the food chain, a process called bioaccumulation (Langlois et al., 2009).

EPA's Toxic Release Inventory Program

Section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA) created the Toxic Release Inventory Program in 1986(US EPA, n.d.-a). The TRI program tracks the management of certain toxic chemicals that may pose a threat to human health and the environment. Under the requirements of EPCRA, all U.S. facilities that meet TRI reporting criteria must submit TRI data to EPA and the states in which they are located by July 1 of each year(US EPA, n.d.). The requirements of being rendered a TRI facility include companies across a wide range of industries (including chemical, mining, paper, oil and gas industries) that produce more than 25,000 pounds or handle more than 10,000 pounds of a listed toxic chemical.

Previous studies have shown Toxic Release Inventory facilities and exposures are concentrated in urban areas with large minority populations (S. M. Wilson et al., 2012). Urban areas are of particular interest due to the large number of exposed individuals across a small area. Atlanta is the ninth-largest metropolitan statistical area in the United States with a population of 5.3 million people. Atlanta and the greater metropolitan region has a very diverse and large minority population with 32% African Americans, 11% Hispanic and the 5% Asian Americans. Atlanta has the largest African American population in the United States and a steadily growing Hispanic population. Because of Atlanta's large minority population and the US history of environmental injustice, it is important to understand if and to what magnitude spatial disparities exist in regards to TRI site location, toxic chemical emissions, and regulation. Furthermore, because there is limited literature on the distribution of TRI facilities and regulation of chemical releases in major southern metropolitan cities, this research may help environmental justice groups in these communities to develop strategies to mitigate the burden of toxic facilities.

1.2 Purpose of Study

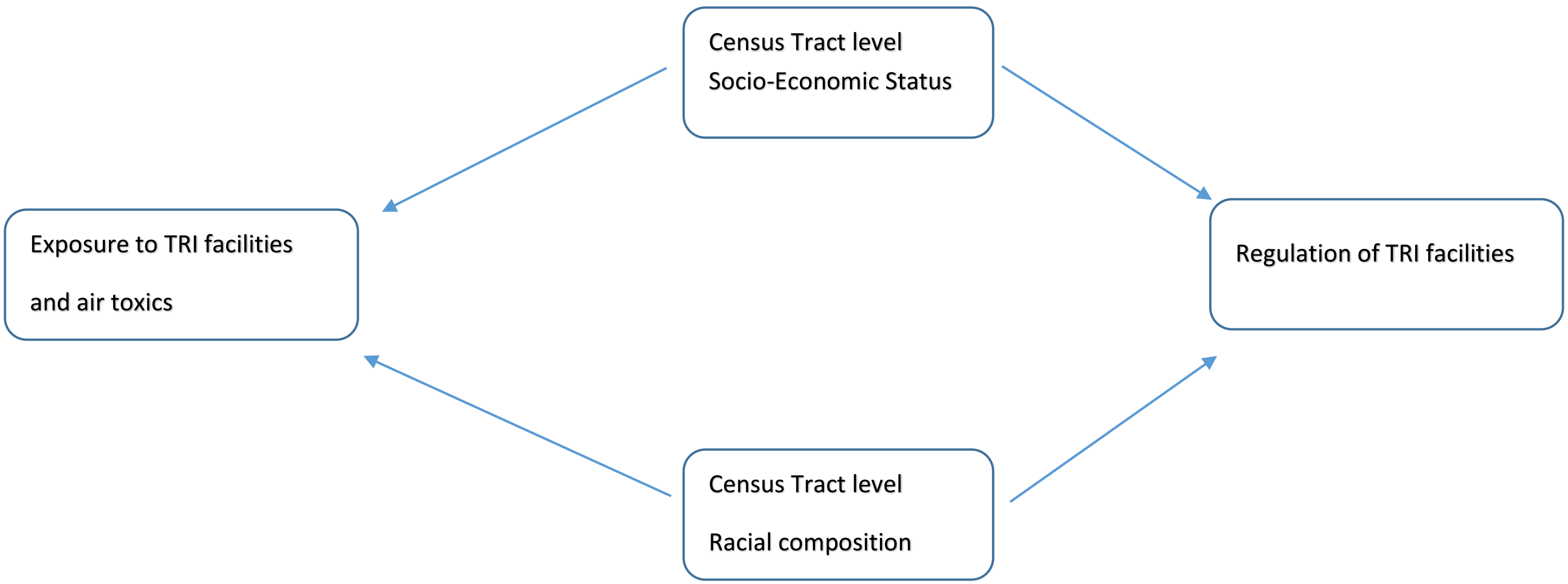
The purpose of this study is to examine the distribution of toxic release inventory (TRI) facilities, emissions of hazardous air chemicals, and the regulation in response to toxic air chemical releases in the Metropolitan Statistical Area (MSA) of Atlanta. Included in the study are 20 counties that are considered the Atlanta Metropolitan Statistical Area (MSA) by the United States Census Bureau. This study aims to ascertain whether the racial and SES composition of census tracts in Atlanta predict the presence of and emissions from TRI facilities. Additionally, this study seeks to examine if complaints and responses to toxic air chemical emissions differ amongst neighborhoods of various SES and racial composition. Examination of the TRI facility location and air chemical releases can help determine whether some populations may have potentially higher risks of exposure and adverse health outcomes in metropolitan Atlanta. Examining differences in complaints to toxic chemical releases and resolution of these complaints can help improve regulation. The objectives of this study are to evaluate the relevance of demographic characteristics to (1) TRI facility location, (2) TRI chemical emissions, and (3) incidence and resolution of facility complaints.

1.3 Research Questions

The specific research questions to be addressed are as follows (Figure 1):

1) Do populations of lower social status and/or minorities face a greater burden of TRI facilities and exposure to air toxics in metropolitan Atlanta?
2) Are complaints related to toxic air chemical emissions and resolution to these complaints different in neighborhoods of lower social status and/or minority?

Figure 1: Proposed relationship between socio-economic status, race, exposure to hazardous chemicals and unhealthy land uses, and regulation of Toxic Release Inventory facilities and unhealthy land uses in the Atlanta MSA



II. Review of the Literature

2.1 Environmental Classism and Racism

Environmental racism is the placement of low-income and/or minority communities in proximity to environmentally hazardous or besmirched environments, such as toxic waste, pollution and urban decay (Bullard, 1993). The interplay between environmental issues and social indicators is vital to the understanding of environmental racism. A significant factor in creation of environmental disparities is the fact that low-income communities lack the organization and political power to resist introduction of dangerous technologies, as well as greater mobility of affluent citizens away from areas falling into industrial and environmental decline (Davidson & Anderson, 2000). Historically, the identification of environmental racism as an injustice began with the environmental justice movement in 1980s in the United States (Martuzzi, Mitis, & Forastiere, 2010). According to the U.S. Government Accountability Office (GAO), in the U.S., there is a correlation between the location of hazardous waste facilities and the ethnic background of an area's residents. In predominantly minority areas, voter registration and education are often lower than average, and citizens are less likely to challenge proposals or seek financial compensation for environmental and health damages (Bullard, 2008).

Implementing techniques to stop hazardous waste sites requires time, money, and political influence or backing (Ringquist, 2005). Resources such as meeting places, access to private and public records, and funding for technical assistance are also required for action. Minority groups may not have full access to these tools and resources creating challenges for the groups in fighting against the placement of toxic sites (Kennedy, 2013). Further, controversial projects are less likely to be sited in areas expected to pursue collective action. Some studies also suggest that the lack of protest could be due to fear of losing area jobs. Non-minority communities are more likely to succeed when opposing the siting of hazardous waste and sewage treatment facilities, incinerators, and freeways in their areas (Bryant, 1995). Non-minority communities have better chance at accessing these tools and resources used to prevent placement of toxic sites and also negative impacts of environmental policy decisions (Bryant, 1995).

Some social scientists see the siting of hazardous facilities in minority communities as a demonstration of intentional racism, whereby these communities are targeted for prejudicial reasons, belief in racial inferiority, or a desire to protect racial group privilege. To the contrary, others see the causes of environmental racism as structural and institutional. The traditional perspective views discrimination as more individualistic, sporadic, and episodic than the institutional perspective.

Processes such as suburbanization, gentrification, and decentralization lead to patterns of environmental racism even absent intentionally discriminatory policies (Pulido, 2000). For example, the process of suburbanization (or white flight) consists of non-minorities leaving industrial zones for safer, cleaner, and less expensive suburban locales (Pulido, 2000). Meanwhile, minority communities remain in the inner cities and in close proximity to polluted industrial zones. In these areas, unemployment is high and businesses are less likely to invest in area improvement, creating poor economic conditions for residents and reinforcing a social formation that reproduces racial inequality. Furthermore, the poverty of property owners and residents in a municipality may be taken into consideration by hazardous waste facility developers since areas with depressed real estate values will cut expenses (Pulido 2000).

2.2 Environmental Exposure Disparities

Toxic Waste and Race in America, published in 1987, was the first comprehensive national report to demonstrate that extensive racial and socioeconomic disparities persist in the distribution of hazardous waste facilities and unhealthy land uses (Mohai & Bunyan, 1987). In 2007, it was estimated in the United States that more than 5.1 million people of color, including 2.5 million Hispanics, 1.8 million African Americans, 616,000 Asian/Pacific Islanders and 62,000 Native Americans lived in neighborhoods with one or more commercial hazardous waste facilities (Bullard, Mohai, Saha, & Wright, 2007). Furthermore, neighborhoods with hazardous waste facilities are 56% people of color whereas neighborhoods without hazardous waste facilities are 30% people of color (Hutch et al., 2011). Disparities also exist in neighborhoods with high poverty rates. Poverty rates in neighborhoods with hazardous waste facilities are 1.5 times greater than neighborhoods without hazardous waste facilities (Bullard 2007). The report also noted more pronounced disparities in major metropolitan areas. In metropolitan areas, where 80% of hazardous waste facilities are located, neighborhoods with these facilities are approximately 60% minority.

In 2008, *Dumping in Dixie: Race, Class, and Environmental Quality*, a new report gave an update to the 1987 “Toxic Waste and Race” findings. In this analysis, year 2000 Census data were used in conjunction with a list of hazardous waste sites to see if there had been some change and improvement in environment inequities (Bullard, Mohai, Saha, & Wright, 2008). Bullard et al. (2008) found that there were still significant racial and socioeconomic disparities in the communities surrounding the hazardous waste sites. In fact, based on the new analysis, minorities were more concentrated near hazardous facilities than what was found in 1987 (Bullard et. al., 2008). Bullard et al. (2008) also looked at state disparities comparing the minority population in hazardous waste host areas versus non-host areas. The authors found that the 44 states with hazardous sites, 90% of them have a higher percentage of minorities in areas containing hazardous sites, also referred to as host areas, in comparison to non-host areas. The ten states with the largest disproportions include the following: California, Nevada, Illinois, Alabama, Michigan, Tennessee, Washington, Arkansas, Kentucky, and Kansas (Bullard et. al., 2008).

Since 1987, there have been numerous reports and studies that reiterated the findings of *Toxic Waste and Race in America* and the subsequent update. A cross-sectional study conducted by Mohai et al. (2009) found that African Americans and respondents at lower educational levels and lower income levels were significantly more likely to live within a mile of a polluting facility. Racial disparities were especially pronounced in metropolitan areas of the Midwest and West and in suburban areas of the South

A study by Wilson et al. conducted in 2012, assessed spatial disparities in the distribution of TRI facilities in Charleston, South Carolina, a major metropolitan port city. The authors aimed to ascertain whether the racial and socio-economic composition of census tracts with a TRI facility differed from the composition of those that did not have a TRI facility. The authors used spatial methods and regression models to assess burden disparities in the study area at the block and census-tract levels by race/ethnicity and SES. Results of regression analyses showed a direct association between presence of TRI facilities in census tracts/blocks and high percentage non-White and an inverse association between number of TRI facilities and high SES.

Kearney & Kiros (2009) used recently developed variations of a distance-based approach to spatially evaluate and compare demographic and socioeconomic disparities surrounding the worst hazardous waste sites in Florida. The authors used data from the 2000 U.S. Census and the Florida Department of Environmental Protection to identify selected census tract level socioeconomic variables within one mile of 71 sites on the National Priorities List (NPL) in Florida (Kearney & Kiros, 2009). Logistic regression was used to determine if race/ethnicity and socioeconomic indicators are significant predictors of the location of NPL sites (Kearney & Kiros, 2009). There were significant differences in race/ethnicity composition and socio-economic factors between NPL host census tracts and non-host census tracts in Florida (Kearney & Kiros, 2009). The percentages of Blacks (OR = 5.7, $p < 0.001$), the percentage of Hispanic/Latino (OR = 5.84, $p < 0.001$), and percent employed in blue-collar occupations (OR = 2.7, $p < 0.01$) were significant predictors of location of NPL facilities. This study supports previous studies and suggests that race and ethnicity play substantial roles in where hazardous facilities are located in Florida.

A study by Mennis & Jordan (2005) showed relationships among race, class, employment, urban concentration, and land use varied significantly with air toxic release density in New Jersey. The authors found a direct significant relationship of minorities with air toxic releases over a large swath of urban and suburban New Jersey. Additionally, Mennis et al. (2005) found the association between minorities with concentrations of air toxic releases is often mediated by other factors, though the role of these mediating factors also varies from place to place. The minority-air-toxic-release association was mediated by high poverty rates, in other areas, by the presence of industrial, commercial, and transportation land uses(Mennis & Jordan, 2005).

2.3 Air toxics and health effects

There is a plethora of studies that have shown evidence of adverse health effects associated with acute and chronic exposure to air toxics. These studies have shown a wide array of health effects of these chemicals. Some of the health effects associated with chronic exposure to air toxics include cancer development, respiratory ailments, as well as neurological, reproductive, and developmental issues (Choi et al., 2006). Ho and Hite (2009) examined the impacts of toxic chemical releases on labor productivity. They hypothesized that exposure to releases results in chronic or acute illnesses, which increases the number of work days lost. To test the hypothesis they combine data from the National Health Interview Survey with data from US Environmental Protection Agency's Toxic Release Inventory. The authors found that the survey respondents were significantly more likely to have increased workdays lost as their exposure to toxic releases increased and that work days lost increased at an increasing rate with diminished health status.

A study by Woodruff et al. (2003) looked at whether exposure to TRI facilities resulted in worse birth outcomes for racial and ethnic minorities and for persons with low socioeconomic status (SES). Woodruff et al. (2003) evaluated whether mothers in groups at higher risk for poor birth outcomes lived in areas of higher air pollution and whether higher exposure to air pollution contributes to poor birth outcomes. They used linear regression to estimate associations between the air pollution index and maternal race and educational attainment, a marker for SES of the mother, controlling for age, parity, marital status and region of the country. They used logistic regression models both to estimate likelihood of living in counties with the highest levels of air pollution for different racial groups and by educational attainment, adjusting for other maternal risk factors, and to estimate the effect of living in counties with higher levels of air pollution on preterm delivery and small for gestational age (SGA). The results displayed Hispanic, African-American, and Asian/Pacific Islander mothers experienced higher mean levels of air pollution and were more than twice as likely to live in the most polluted counties compared with white mothers after controlling for maternal risk factors, region, and educational status. Furthermore, there was a small increase in the odds of preterm delivery but not in a county with high air pollution.

Choi et al. (2006) evaluated whether mothers of childhood brain cancer cases had greater potential residential exposure to TRI chemicals than control mothers during pregnancy. The authors included 382 brain cancer cases diagnosed at < 10 years of age from 1993 through 1997 who were identified from four statewide cancer registries. One-to-one matched controls were selected by random-digit dialing. Computer-assisted telephone interviews were conducted. Using residential history of mothers during pregnancy, proximity to TRI facilities and exposure index was measured, including mass and chemicals released. Increased risk was observed for mothers living within 1 mi of a TRI facility (OR = 1.66; 95% CI, 1.11–2.48) and living within 1 mi of a facility releasing carcinogens (OR = 1.72; 95% CI, 1.05–2.82) for having children diagnosed with brain cancer before 5 years of age, compared to living > 1 mi from a facility. The authors concluded risk of childhood brain cancers may be associated with living near a TRI facility; however, further studies are needed.

Rice et al. (2014) examined estimated lifetime cancer risk from air toxics by racial composition, segregation, and deprivation in census tracts in Metropolitan Charleston. Segregation indices were used to measure the distribution of groups of people from different races within neighborhoods. The authors found lifetime cancer risk from all pollution sources was 28 persons/million for half of the census tracts in Metropolitan Charleston. Isolation Index and Townsend Index both showed significant correlation with lifetime cancer risk from different sources. This significance still holds after adjusting for other socio-demographic measures in a Poisson regression, and these two indices have stronger effect on lifetime cancer risk compared to the effects of socio-demographic measures. The authors concluded material deprivation, measured by the Townsend Index and segregation measured by the Isolation index, introduced high impact on lifetime cancer risk by air toxics at the census tract level.

2.4 Regulation Differences

There is limited literature on whether regulation processes of air toxic emissions from TRI facilities. There have been studies that confirm exposure disparities to TRI facilities and emissions. It is reasonable to believe that regulation disparities also exist in disadvantaged communities. Stuart, Mudhasakul, & Sriwatanapongse, (2009) studied the potential for inequities between population subgroups in air pollution exposures and in regulatory protection because of small-scale urban differences in outdoor air pollution and air quality monitoring. The focus subgroups were blacks, Hispanics, whites, and the population living below poverty, with Tampa, FL, used as the case study area for quantitative analyses (Stuart et al., 2009). A geographical database was developed for the surrounding county that includes population demographics, source locations, monitor locations, and air pollutant concentrations.

The authors used data from residential population demographics at the block-group spatial scale from the year 2000 U.S. Census, U.S. Environmental Protection Agency (EPA) Toxic Releases Inventory source locations and air source release amounts, EPA Air Quality System monitoring data, and Florida major highway source locations and roadway traffic data. Findings include that blacks, Hispanics, and people living in poverty are disproportionately living closer to sources of air pollution and further from regulatory air quality monitoring sites compared with the overall county population(Stuart et al., 2009). Conversely, whites are disproportionately living away from sources and near monitoring sites. Analysis of the regulatory monitoring guidelines indicates that recent changes in those guidelines may exacerbate existent inequities. The results suggest disparities in exposures to air pollution, disparities in regulatory monitoring representation, and the need for more monitoring and analyses at smaller spatial scales(Stuart et al., 2009).

Hird (1993) studied Superfund sites at the national and county level and concluded the wealthy were more likely to be represented in the Superfund cleanup program. It was noted in this study that minorities are more likely to live in close proximity to hazardous sites; however these sites are less likely to be listed on the NPL (Hird, 1993). Some researchers suggest that when a wealthier population is more likely to live in proximity to a hazardous site listed on the NPL, they are more likely to benefit from the resources from the federal government (O'Neal, 2007). On the other hand, some researchers suggest that minorities and poorer populations are experiencing environmental injustice since a larger proportion is living in close proximity to the NPL sites (Zimmerman, 1993).

These studies have noted that monitoring and cleanup of toxic chemicals are different in areas of various socio-demographic characteristics. However, to our knowledge there have been no studies that have examined how communities respond to toxic chemical emissions by way of complaints/reports on chemical emissions. Furthermore, no studies have looked at whether these complaints are handled in an adequate manner and comparable to affluent or advantaged communities.

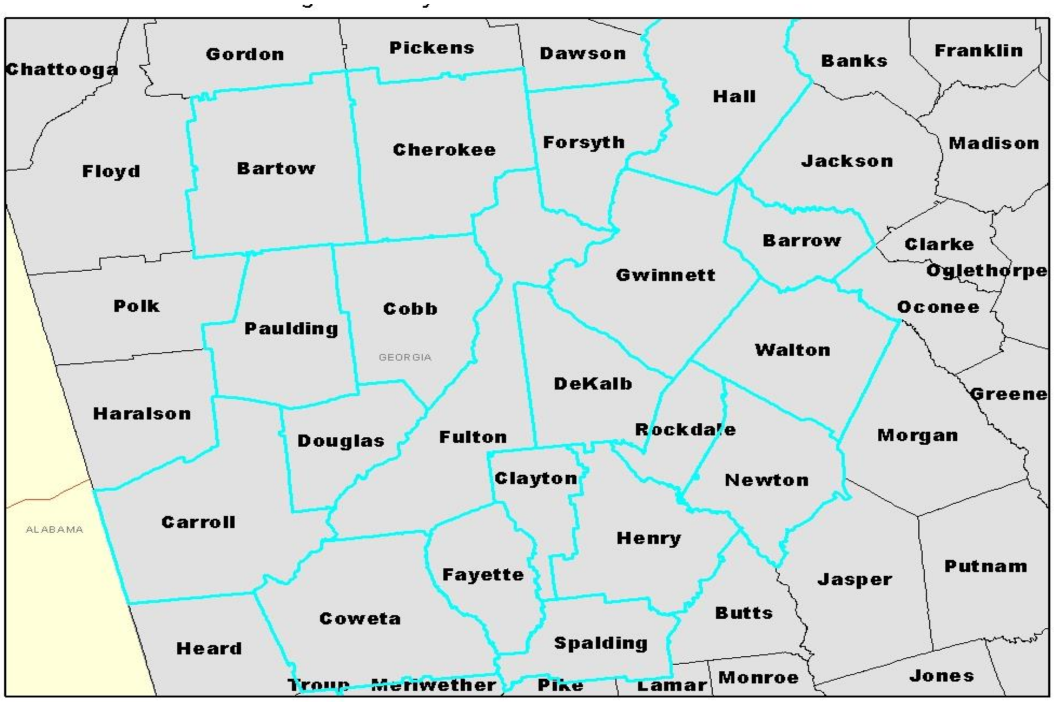
III. Methodology

Data Sources. The data for this study were derived from the Environmental Protection Agency's Toxic Release Inventory (TRI) program, a publicly available database containing information on toxic chemical releases and other waste management activities in the United States (years 2006-2011); year 2000 demographic data from US Census Bureau Summary Files 1 and 3; and Georgia's Environmental Protection Division (EPD) data on complaints to hazardous chemicals from 2006-2011.

We extracted year 2000 census-tract data from the United States Census Bureau Summary files. We extracted years 2006-2011 TRI data from an EPA database by using the EPA's TRI Explorer and mapped TRI facility locations in the Atlanta metropolitan statistical area (MSA) using ArcMAP 10.1 (Environmental Systems Research Institute, Redlands, CA), using latitude---longitude coordinates. Geographical coordinates were used to match each toxic release inventory facility to its respective census tract. Data on complaints to toxic chemical releases were requested from Georgia EPD via an Open Records Request. Under the Georgia Open Records Act, all public records are available for inspection and copying unless they are specifically exempt from disclosure under the law. Census tracts were derived from Georgia's Environmental Protection Division complaint data by geocoding the pollution source address. Once all three data sets had the unique identification census tract number, they were merged.

Geographic coverage. The Atlanta MSA designated by the United States Office of Management and Budget is comprised of 20 counties. This area was chosen because previous studies suggest that highly populated urban areas face some of the most pronounced exposure disparities, however, there have been few studies that have looked at exposure disparities in major southern metropolitan cities. Metro Atlanta is the most populous metro area in the state of Georgia, the ninth-largest MSA in the United States, and the fourth largest MSA in the south (Houston, Dallas, and Miami). The counties included in the Atlanta MSA are Barrow County, Bartow County, Carroll County, Cherokee County, Clayton County, Cobb County, Coweta County, DeKalb County, Douglas County, Fayette County, Forsyth County, Fulton County, Gwinnett County, Hall County, Henry County, Newton County, Paulding County, Rockdale County, Spalding County and Walton County (Figure 1).

Figure2: Atlanta Metropolitan Statistical Area



Atlanta MSA outlined in light Blue

Target area. The target area for this study is census tracts within the Atlanta MSA, whose populations may face potential harm from Toxic Release Inventory facilities. The sample includes all facilities that meet the EPA's requirements for being considered a TRI designated site in metropolitan Atlanta.

Unit of Analysis. The unit of analysis will be census tracts. We are measuring the difference in facility location, chemical emissions, and regulation processes in tracts of differing socio-demographic characteristics. Additionally, we are measuring the regulation processes by whether complaints and resolution of complaints from toxic chemical emissions differ by socio-demographic in these census tracts. There are total 657 census tracts in the Atlanta MSA and therefore, 657 observations.

Socio-demographic data. This study used year 2000 demographic data from the United States Census Bureau. We used data at the census tract level to enumerate the socio-demographic characteristics of all the census tracts in the Atlanta MSA. In particular, census-tract level data was used to enumerate the characteristics of populations burdened by TRI facilities, toxic air chemical exposures, and unequal regulation, focusing on race/ethnicity and socio-economic status (SES). The SES variables used include measures of the following: race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic and Asian), poverty (residents living below the national poverty level and residents on public assistance), educational attainment (population older than 24 years with <high school education vs those with a undergraduate degree vs those with a graduate/professional degree), and vacant housing (proportion of house vacant). We also obtained median household income for each census tract in the Atlanta MSA. Many of these variables were used in previous studies to assess socio-demographic disparities in the distribution of noxious facilities.

Toxic Release Inventory Data. A self-administered reporting form collects the data annually. Data are submitted annually by covered facilities on a toxic chemical release inventory form, or Form R, which is a self-administered reporting form, to the EPA and a state-designated agency (Environmental Protection Division for Georgia). Data are reported by individual chemical or category on a facility basis. EPA examines these data for reporting errors and then compiles them into a centrally managed database. Data is collected annually from facilities that meet all three of the EPA's criteria. These criteria are (1) employs 10 or more fulltime equivalent employees, (2) manufactures or processes more than 25,000 lbs. of a TRI-listed chemical or otherwise uses more than 10,000 lbs. of a listed chemical in a given year, and/or (3) are TRI-Covered Industries of mining, utilities, manufacturing, merchant wholesalers, non-durable goods, wholesale electronic markets, and agents brokers publishing, and hazardous waste. Furthermore, we restricted our analysis to TRI facilities emitting air toxics.

Census Tract Data. The United States Census Bureau collected this data by a mail canvass of appropriate state government offices that are directly involved with state-administered taxes. There were approximately one hundred offices that are canvassed to collect data from all fifty states. Follow-up procedures include the use of mail, telephone, and e-mail until data are received. Respondents were sampled using cluster-sampling techniques. Data were processed from several collection methods including direct response to survey forms from state government officials, as well as from the compilation of administrative records and supplemental sources. Data are edited using ratio edits of the current year's value to the prior year's value. Not all respondents answer every item on the survey. The U.S. Census Bureau uses imputation, which is the process of filling in missing or invalid data with reasonable values in order to have a complete data set for analytical purposes. Census tract data was downloaded from US Census Bureau website. This data was filtered to only include the 20 counties that are considered a part of the Atlanta MSA.

Complaint Data. We requested complaints related to air quality issues to the Georgia Environmental Protection Division (EPD). EPD provided all primary and secondary complaints to air quality issues. We then matched the source addresses of the complaints with a census tract.

Outcomes variables. The total amount of toxic air chemicals emitted in pounds, the presence/absence of a TRI facility, and the amount of toxic air chemicals emitted per release are the main outcome variables (Table 2). Furthermore, complaints on air toxic emissions and the resolution of these complaints were the main outcome measures used to measure whether the regulation processes of toxic chemical emissions differ by socio-demographic characteristics in the Atlanta MSA tracts. Tables 1 and 2 provide a brief description of the predictor and outcome variables used in this study.

Statistical Analysis. SAS version 9.3 was used to perform statistical analyses for this study. We perform basic descriptive statistics on all socio-demographic, TRI and EPD complaint data. Logistic regression was used to assess the relative importance of race/ethnicity and socioeconomic variables in predicting whether a TRI facility was located in a census tract (the dependent variable). The dependent variable was coded 1 if a TRI facility was located within the census tract and 0 if the there was no TRI facility in the census tract. We applied linear regression models to examine the association between amount of air toxics released from TRI facilities in the census tract (dependent variable), the number of emissions from TRI facilities in the census tract (dependent variable) and the amount of chemicals released per emission (dependent variable) and socio-demographic variables at the census tract level (independent variables). Additionally, ordinal logistic regression was used to evaluate the association between the number of complaints to toxic chemicals (dependent variable) and time to resolution of complaints (dependent variable) and the covariates (SES and race/ethnicity) at the census tract level.

Table 1: Census tract variables used to evaluate demographic and economic characteristics

Name	Description
Race	Percent of persons who identify as White, Black, Hispanic, Asian in a given census tract
Median household income	Median HH income in 1999, across all households in a given census tract
Families Living in Poverty	Families income in 1999 below poverty in given census tract
Education attainment	Persons 18 or older with a high school diploma; bachelor degree; graduate or professional degree in a given census tract
Total Population	All people, male, female, child, adult living in a given census tract
Vacant housing	Total number of vacant housing units in a given census tract
Occupied Housing	Total number of occupied housing units in a given census tract

Table 2: Toxic Release Inventory variables used to evaluate exposure to toxic chemicals and unequal regulation

Name	Description
TRI facility presence	Dichotomous variable that states whether a census tract has a TRI site that emit air toxics (Yes/No)
Sum of Toxic air Chemical Emission	Amount of air Toxic Chemicals emitted in a given census tract in pounds (lb)
Toxic chemical releases	Number of toxic air chemicals emissions in a given Census Tract
Average Toxic air Chemical Emission	Average amount toxic air chemical emitted per emission in a given census tract
Complaints	Number of complaints related to toxic air chemical emissions in a given census tract
Resolution Time	Average time for complaints to be resolved in a given census tract

IV. Results

4.1 TRI facility distribution

Figure 2 is a map, created in ArcMap 10.1, illustrating the distribution of Toxic Release Inventory Facilities in the Atlanta MSA. The map displays that TRI facilities are distributed in clusters in the Atlanta MSA. As shown in figure 2, the approximately 922 TRI facilities in the Atlanta MSA are concentrated in only 135 census tracts. Descriptive analysis show that census tracts composed of a high percentage of lower-middle class residents ($22,500 - $55,000 household income) have disproportionately more TRI facilities than more affluent neighborhoods (Table 8). A high percentage is categorized as being more than 50% of the population having a certain characteristic. Specifically, 59.3% of TRI facilities are located in lower middle class census tracts. In addition, census tracts composed of higher percentages of African Americans and Hispanics are more likely to have a TRI facility present in their census tract. Census tracts with a TRI facility present have about 3% more Hispanics and African Americans than a census tract without a TRI facility. Educational attainment was higher in census tracts without TRI facilities. Census tracts with TRI facilities had on average 4% fewer females with a college degree than census tracts with TRI Facilities.

Bivariate analysis shows a statistically significant association between the presence of a toxic release inventory facility and median household income, high school diploma attainment, undergraduate degree attainment and graduate degree attainment (Table 6). We wanted to look at three categories of socio-demographic characteristics, income, education attainment and racial composition. We used theory to build our models. We used racial composition (black, Hispanic and non-white and SES (income and female college degree attainment) as predictors.

Previous studies have used these variables as predictors of census socio-demographic characteristics. We fit a multivariate logistic regression to evaluate the association between the presence in a census tract of a TRI facility and SES and racial/ethnic composition variables. After we adjusted for the multiple socio-demographic variables, median household income, percentage of college graduates, and percentage of blacks were the only variables significantly associated with the presence of a toxic release inventory facility (Table 9). The log-odds that a census tract contained a TRI facility decreased by 0.11 (odds ratio = 0.89, P = .0002) for each 1% increase of females with a college degree, by 0.015 (odds ratio = 0.98, P = 0.0005) for each 1% increase of black population and by 0.88 (odds ratio = 2.4, P < 0.0001) for each 1% increase of household with an income of $22,000-$55,000.

Figure 3: Toxic Release Inventory Facilities in the Atlanta MSA (2006-2011)

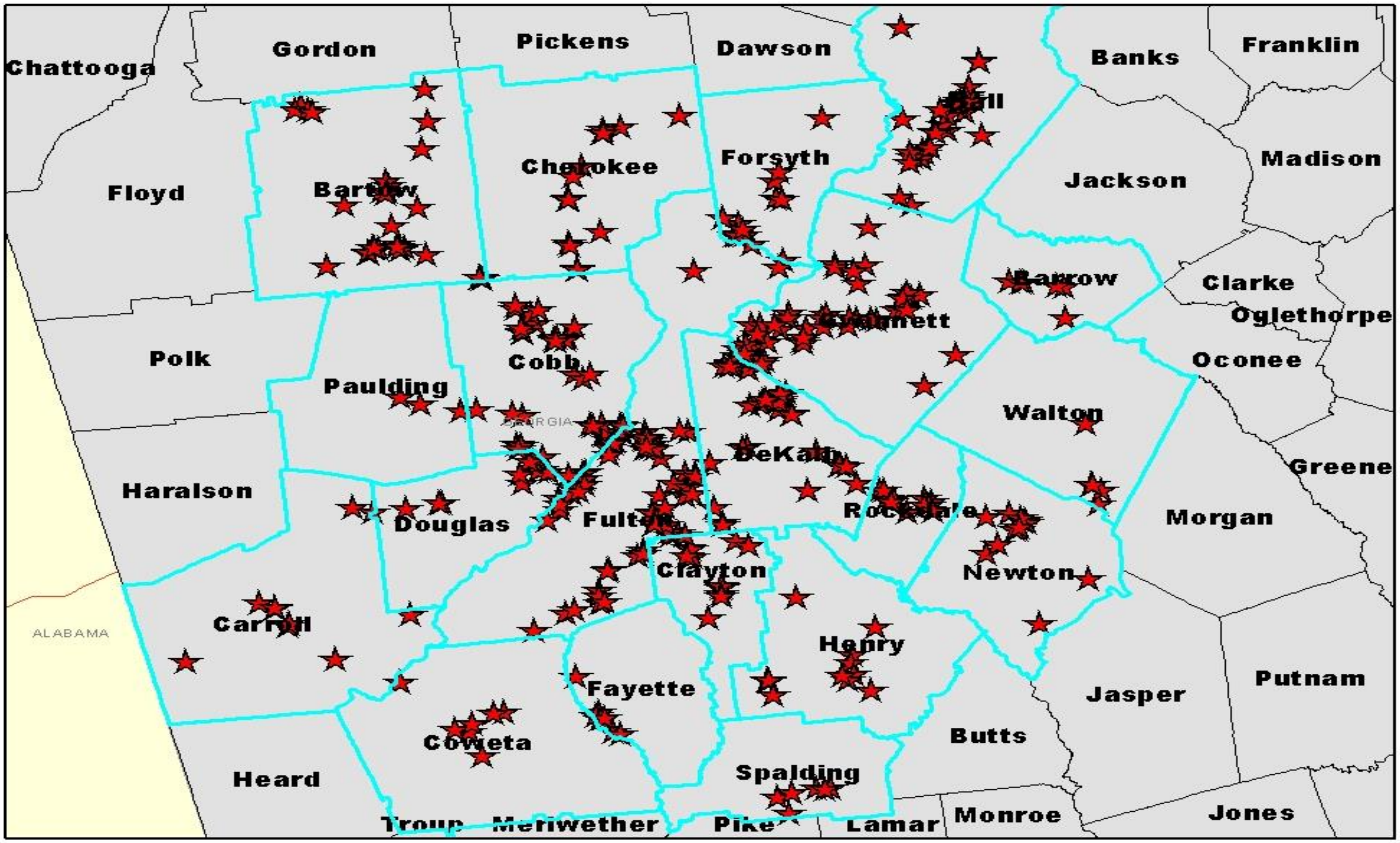


Table 3: [a]Socio-demographic characteristics of all census tracts within the 20 county Atlanta MSA (N=676)

Variable	Mean	Median	Std Dev	Min	Max	Lower Quartile	Upper Quartile
Median Household Income[b]	51816	48081	22345	4705	163474	37223	63075
% of population are female HS graduates	8.6	8.8	3.1	0	16.2	6.3	11.0
% of population are females with undergraduate degree	8.4	7.6	4.8	0	22.0	4.7	11.5
% of population are females with graduate degree	3.0	2.2	2.8	0	40.0	1.2	3.8
% of population White	56.1	68.2	32.7	0	100.0	23.7	85.7
% of population Non-White	42.1	29.8	32.7	0	100.0	12.6	72.2
% of population Black	32.7	16.8	33.2	0	100.0	6.3	57.0
% of population Hispanic	6.5	3.3	9.3	0	71.2	1.6	6.9
% of population Asian	2.9	1.7	3.6	0	20.5	0.4	3.8
% of households with income below the poverty line	11.4	7.8	11.3	0	75.4	4.3	13.9
% of households on public assistance	2.8	1.5	3.8	0	30.0	0.7	3.3
% of housing units vacant	5.6	4.7	4.4	0	57.9	3.1	6.6

[a]Values provided as percentages unless otherwise noted
[b]Median household income given in dollars.

Table 4: Descriptive statistics of primary outcome variables for census tracts with at least one Toxic Release Inventory facility (N=135)

Variable	N Miss	Mean	Median	Std Dev	Min	Max	Lower Quartile	Upper Quartile
[e]Total # of air toxic emissions	0	19.8	10.0	27.0	1.0	218.0	4.0	24.0
[ce]Total amount of air toxics emitted	0	851634.7	4055.0	5592370.4	0	57154971.1	51.0	59137.9
[ce]Amount of air toxics emitted per emission	0	18250.4	260.8	84447.1	0	742272.4	5.9	2566.5
Total # of complaints to air pollution	0	0.9	0	3.6	2.2	33.0	0	1.0
[de]Average time to resolve complaint	38	36.4	5.0	65.7	0	386.0	1.0	44.6

[c]Amount of air toxics in pounds (lbs)
[d]Number of days to resolve complaint
[e]Includes only census tracts with TRI facilities

Table 6: Logistic Regression Bivariate associations and unadjusted odds ratios for outcome TRI facility in census tract (Facility Present vs No Facility Present) (N=676)

Census Tract Characteristics (Predictor)	Facility Present N=135	No Facility Present N=541	BETA ESTIMATE	OR (95% CI)	P value[2]
Median Household Income					
>$77,500	6(4.4%)	69(12.8%)		1.00	
$50,000 – $77,500	42(31.1%)	197(36.4%)	0.16	2.5 (1.0 - 6.0)	0.4
$22,500 - $50,000	80(59.3%)	234(43.3%)	0.63	3.9 (1.6 – 9.4)	0.005
<$22,500	7(5.2%)	41(7.5%)	-0.06	2.0 (0.6 – 6.2)	0.85
% of population White, Median (IQR)	65.6 (44.0 – 83.4)	70.2 (21.6 – 87.0)	0.00350	1.004 (0.998, 1.009)	0.2302
% of population non-White Median (IQR)	32.5 (15.5 – 54.2)	27.9 (11.6 – 75.2)	-0.00328	0.997 (0.991, 1.002)	0.2616
% of population Black Median (IQR)	17.5 (8.4 - 34.6)	16.1 (5.5 – 63.6)	-0.00708	0.993 (0.987, 0.998)	0.0240
% of population Hispanic Median (IQR)	4.5 (2.0 – 10.9)	2.9 (1.3 – 5.9)	0.0286	1.03 (1.013, 1.049)	0.0007
% of population Asian Median (IQR)	0.9 (0.2 – 3.6)	1.6 (0.3 – 3.6)	-0.00838	0.992 (0.941, 1.044)	0.7517
% of Female HS diploma Median (IQR)	9.6 (7.3 – 11.5)	8.5 (6.0 – 10.9)	0.108	1.115 (1.050, 1.183)	0.0009
% of Female Undergrad degree Median (IQR)	5.7 (3.8 – 9.0)	8.3 (5.0 – 12.1)	-0.1015	0.904 (0.865, 0.944)	<0.0001
% of Female Grad degree Median (IQR)	1.8 (0.9 -2.7)	2.3 (1.2 -3.9)	-0.1947	0.823 (0.745, 0.909)	0.0001
% of population with income below poverty line Median (IQR)	10.7 (5.6 – 16.2)	7.7 (4.0 – 13.8)	0.00196	1.002 (0.986, 1.018)	0.8119
% of Housing Vacant Median (IQR)	5.3 (3.8 – 7.3)	4.7 (3.9 – 6.8)	0.0167	1.017 (0.983, 1.052)	0.3396
% of Households on Pub Assist Median (IQR)	2.1 (1.0 – 3.7)	1.5 (0.7 – 3.3)	0.00171	1.002 (0.955, 1.051)	0.1466

[2]Wald Chi-square test used unless note

[H]Table 7: Results: Multivariate Logistic Regression Model Toxic Release Inventory Facility Presence/Absence and Socio-demographic characteristics

Census Tract Characteristics	Unadjusted OR	Adjusted OR*	P Value
Median Household Income			
>$77,500	1.00	1.0	
$50,000 – $77,500	2.5 (1.0 - 6.0)	1.7 (0.6, 4.3)	0.8
$22,500 - $50,000	3.9 (1.6 – 9.4)	2.4 (1.8, 6.7)	0.05
<$22,500	2.0 (0.6 – 6.2)	1.7 (0.4, 8.0)	0.9
% of population Hispanic	1.03 (1.013, 1.049)	1.012 (0.994, 1.032)	0.2
% of population Black	0.993 (0.987, 0.998)	0.985 (0.977, 0.993)	0.0005
% of population female undergrad degree	0.904 (0.865, 0.944)	0.894 (0.842, 0.949)	0.0002

[H]Adjusted model included the following covariates: Median Household Income, % of population Hispanic, % of population black, % of population female with an undergraduate degree.

4.2 <u>Amount of toxic air chemical emissions</u>

We used multiple linear regression to examine the association between amount of air toxics released from TRI facilities in the census tract (dependent variable), the number of emissions from TRI facilities in the census tract (dependent variable) and the amount of chemicals released per emission (dependent variable) and socio-demographic variables at the census tract level (independent variables). Using Tukey's ladder, the main outcome variables, total amount of chemicals emitted and amount of chemicals emitted per emission, were LOG10 transformed to mitigate violations of the linearity and normality assumptions. Furthermore, percent of population female with an undergraduate degree, percent of population Hispanic and percent of population black were also LOG10 transformed. This changed the interpretation of the slope coefficients.

The unadjusted Pearson's correlation showed that total the amount of air toxics emitted in the years 2006-2011 in pounds has a moderate negative association with percent of population that are females with undergraduate degree (r = -0.20, P = 0.0018), a moderate negative association with percent of population are females with graduate degree (r= -0.25, P= 0.0037) and a moderate negative association with percent of population with median household income (r= -0.16, P=0.006). For the amount of air toxics emitted per emission, the unadjusted Pearson's correlation showed that it has a moderate negative association with percent of population are females with undergraduate degree (r = -0.27, P = 0.0021) (Table 5), a moderate negative association with percent of population are females with undergraduate degree (r= -0.23, P= 0.007) and a moderate negative association with percent of population are females with graduate degree (r= -0.16, P=0.006) (Table 5).

Bivariate analysis shows a statistically significant association between the amount of chemicals released and median household income, undergraduate degree attainment and graduate degree attainment (Table 9). Similarly, bivariate analysis shows a statistically significant association between the amount of chemicals emitted per emission and median household income, undergraduate degree attainment and graduate degree attainment (Table 9). We did not find any significant bivariate associations for the number of emissions and the socio-demographic and therefore did not create a multivariate model (Table 9).

We wanted to look at three categories of socio-demographic characteristics; income, education attainment and racial composition. We used theory to build our models based on the literature. To evaluate the association between the amounts of toxic air chemicals emitted from TRI facilities and both SES and race/ethnicity, we fitted two multivariate linear regression models. One of the models had the main outcome, total amount of air toxics emitted in the years 2006-2011 in pounds and the other model had the main outcome, amount of chemicals emitted per emission in the years 2006-2011. After adjusting for multiple socio-demographic variables, percentage of females with a college degree was the only variable significantly associated with the amount of toxic air chemicals emitted (Table 10). The estimated difference in the amount of chemicals emitted associated with a one-percentage point difference corresponding to a 10-fold difference in percent of population are females with undergraduate degree – adjusting for median household income and % of population non-white is -1853.0 pounds. Thus, on average, the lower education census tracts with TRI facilities had more chemicals emitted that higher education census tracts with TRI facilities (β=-0.1853, P= 0.009). Additionally, census tracts with lower percentage of female college graduates had more chemicals emitted per emission (Table 10). The estimated difference in the amount of chemicals emitted per emission associated with a one-percentage point difference corresponding to a 10-fold difference in percent of population are females with undergraduate degree – adjusting for median household income and % of population non-white is -18.0 pounds (Table 10). Thus, on average, the lower education census tracts with TRI facilities had more chemicals emitted that higher education census tracts with TRI facilities (β=-0.18, P= 0.004).

*4.3 **Number of releases from TRI facilities***

The unadjusted Pearson's correlation showed that number of emissions from 2006-2011 had no statistically significant association with any other socio-demographic characteristics studies. Furthermore, bivariate analysis shows no statistically significant association between any of the socio-demographic characteristics and the number of toxic air chemical emissions in the years 2006-2011 (Table 9). A multivariate model was not used because of no bivariate relationship between socio-demographic predictors and the number of emissions in a given census tract.

[FG]Table 8: Pearson's Correlation Coefficient for Total # of air toxic emissions, Total amount of air toxics emitted, Amount of air toxics emitted per emission and Socio-Demographic Variables (N=135)

Pearson's Correlation Coefficients, P Values N = 135																
	Total Chemicals Emitted	Avg. Chemicals Emitted	Number of emissions	Median HH income	HS Diploma	Undergraduate Degree	Graduate Degree	White	Non-White	Black	Hispanic	Asian	Below Poverty Line	Public Assistance	Vacant Housing %	Resolution Time
Total Chemicals Emitted	1.0															
Avg. Chemicals Emitted	0.96 <.0001	1.0														
Number of emissions	0.56 <.0001	0.35 <.0001	1.0													
Median HH income	-0.16 0.06	-0.16 0.06	-0.11 0.23	1.0												
HS Diploma	0.04 0.62	0.05 0.59	0.03 0.76	-0.15 0.08	1.0											
Undergraduate Degree	-0.25 0.0037	-0.27 0.0021	-0.10 0.26	0.68 <.0001	-0.46 <.0001	1.0										
Graduate Degree	-0.20 0.018	-0.23 0.007	-0.05 0.56	0.55 <.0001	-0.40 <.0001	0.78 <.0001	1.0									
White	-0.11 0.21	-0.10 0.25	-0.09 0.28	0.50 <.0001	0.39 <.0001	0.13 0.12	0.07 0.45	1.0								
Non-White	0.11 0.1981	0.10 0.24	0.10 0.26	-0.50 <.0001	-0.14 0.098	-0.14 0.09	-0.07 0.44	-1.0 <.0001	1.0							

Black	0.05 0.55	0.05 0.58	0.053 0.54	-0.54 <.0001	-0.14 0.09	-0.17 0.05	-0.05 0.57	-0.85 <.0001	0.90 <.0001	1.0						
Hispanic	0.13 0.13	0.09 0.29	0.11 0.19	-0.10 0.25	-0.38 <.0001	0.06 0.51	0.005 0.95	-0.34 <.0001	0.30 0.0001	-0.02 0.84	1.0					
Asian	0.14 0.16	0.11 0.26	0.07 0.49	0.31 0.0009	-0.53 <.0001	0.49 <.0001	0.35 0.0002	-0.27 0.0049	0.25 0.0069	0.006 0.95	0.41 <.0001	1.0				
Below Poverty Line	0.06 0.46	0.04 0.65	0.11 0.20	-0.86 <.0001	0.05 0.56	-0.57 <.0001	-0.39 <.0001	-0.56 <.0001	0.57 <.0001	0.55 <.0001	.19 0.03	-0.18 0.05	1.0			
Public Assistance	0.09 0.34	0.11 0.22	0.04 0.64	-0.74 <.0001	0.27 0.0019	-0.62 <.0001	-0.45 <.0001	-0.39 <.0001	0.41 <.0001	0.47 <.0001	-0.063 0.48	-0.32 0.007	0.70 <.0001	1.0		
Vacant Housing %	0.07 0.43	0.11 0.23	-0.006 0.94	-0.58 <.0001	0.16 0.07	-0.38 <.0001	-0.25 0.004	-0.15 0.08	0.16 0.07	0.28 0.0012	-0.048 0.58	-0.35 0.002	0.53 <.0001	0.41 <.0001	1.0	
Resolution Time	0.10 0.38	0.08 0.47	0.14 0.24	0.096 0.41	-0.22 0.05	0.03 0.80	-0.09 0.42	-0.07 0.54	0.07 0.53	-0.035 0.76	0.11 0.33	0.087 0.49	-0.012 0.92	-0.20 0.08	-0.22 0.05	1.0

[F]Only census tracts with TRI facilities were included
[G]Logarithim10 transformed all variables to normalize

Table 9: Simple Linear Regression of the relation between total amount toxic air chemicals emitted in pounds/Amount Toxic Chemicals emitted per emission and socio-demographic variables. (N=135)

Census Tract Characteristics (Predictor)	**Total Amount Toxic Air Chemicals Emitted**			**Average Toxic Air Chemicals per Emission**			**# of Toxic Air Chemical Emissions**		
	Slope Coefficient	95% CI	P-Value	Slope Coefficient	95% CI	P-Value	Slope Coefficient	95% CI	P-Value
Med HH Income	-0.00002	-0.00005, 0.0000030	0.08	-0.000020	-0.00004, 0.000003	0.08	-0.000003	-0.000008, 0.0000003	0.32
% White	-0.008	-0.022, 0.0058	0.25	-0.007	-0.020, 0.0056	0.28	-0.0019	-0.0051, 0.0014	0.25
% non-White	0.0085	-0.0056, 0.023	0.24	0.0070	-0.006, 0.020	0.27	0.0020	-0.0013, 0.0052	0.23
% Black	0.0027	-0.012, 0.017	0.72	0.0023	-0.011, 0.015	0.73	0.00090	-0.0025, 0.0042	0.60
% Hispanic	0.47	-0.27, 1.21	0.21	0.40	-0.30, 1.02	0.30	0.093	-0.080, 0.262	0.28
% Asian	0.50	-0.27, 1.24	0.20	0.37	-0.29, 1.03	0.27	0.097	-0.076, 0.270	0.27
% Female HS Grad	0.04	-0.09, 0.17	0.60	0.04	-0.08, 0.15	0.60	0.0035	-0.027, 0.034	0.82
% of Female Undergrad degree	-0.15	-0.24, -0.053	0.003	-0.14	-0.22, -0.06	0.001	-0.013	-0.035, 0.010	0.26
% of Female Grad degree	-1.34	-2.45, -0.23	0.02	-1.32	-2.30, -0.35	0.008	-0.085	-0.34, 0.17	0.52
% households with income below poverty line	0.53	-0.72, 1.80	0.40	0.41	-0.70, 1.51	0.47	0.17	-0.12, 0.45	0.24

% of Housing Vacant	0.78	-1.10, 2.70	0.41	0.81	-0.86,2.50	0.34	0.061	-0.16, 0.28	0.60
% of Households on Pub Assist	0.56	-0.41, 1.53	0.26	0.56	-0.31, 1.42	0.20	0.055	-0.38, 0.49	0.80

* total amount of chemicals emitted, amount of chemicals emitted per emission, percent of population female with a undergraduate degree, percent of population Hispanic and percent of population black were LOG10 transformed

[H]Table 10: Results: Multivariate Linear Regression Model the relation between total amount toxic air chemicals emitted in pounds/Amount Toxic Chemicals emitted per emission and socio-demographic variables. (N=135)

Census Tract Characteristics	Total Amount Toxic Air Chemicals Emitted		Average Toxic Air Chemicals per Emission	
	Slope Coefficient (95%CI)	**P Value**	**Slope Coefficient (95%CI)**	**P Value**
Median Household Income	0.0000082	0.62	0.000011	0.50
% of population female undergrad degree	-0.1853	0.009	-0.18	0.004
% of population Non-White	0.0080	0.35	0.0061	0.37

[H]Adjusted model included the following covariates: Median Household Income, % of population female with an undergraduate degree and % of population non-white

* total amount of chemicals emitted, amount of chemicals emitted per emission, percent of population female with a undergraduate degree, percent of population Hispanic and percent of population black were LOG10 transformed

4.4 Complaints to air toxic chemical emissions

The number of complaints to toxic chemicals was correlated with racial composition of census tract (Table 11). The percent of population non-white was slightly negatively associated with the number of complaints to toxic air chemical emission ($\rho = -0.10$, $P = 0.009$). Census tracts with a higher non-white percentage of the population were less likely to report an air toxic chemical emission. To the contrary, the larger the percentage of whites, the more likely a census tract was to report a toxic air chemical emission ($\rho = 0.09$, $P = 0.02$). When evaluating racial/ethnic groups individually, higher percentage of the population black and Asian was negatively correlated with complaints to air toxic emission ($\rho = -0.09$, $P = 0.02$ and $\rho = -0.14$, $P = 0.0007$, respectively). Overall, census tracts composed of a high percentage of minority residents are less likely to complain and report toxic chemical emissions. Education attainment was correlated with the number of complaints to toxic chemical emissions (Table 11). The percentage of female college graduates in the census tract is inversely correlated with the number of complaints ($\rho= -0.13$, $P = 0.0007$). As the percentage of college graduates in a census tract increases the number of air toxic complaints decreases.

To evaluate the association between the number of complaints to air toxic emissions in census tract with SES and race/ethnicity, we fitted an ordinal logistic regression model on complaint categories. The complaint categories included no complaints, one complaint and two or more (multiple) complaints to a source within the census tract. After adjusting for multiple socio-demographic variables, percent of population black, percent of population Hispanic, percent of population Asian, percent of population female HS diploma, percent of population female undergraduate degree were statistically significantly associated with the number of complaints toxic air chemicals emitted (Table 13). Those census tracts that had multiple complaints to air to toxics had 4.3% fewer minority residents then the census tracts that had no complaints (β=0.006, P= 0.009) (Table 13). The percent of population black (OR=0.991, P = 0.0072), Hispanic (OR =1.025, P = 0.014), and Asian (OR 0.928, P= 0.0061) were significantly associated with the number of complaints to toxic chemical emissions controlling for median household income, TRI facility presence, and percent of population female with an undergraduate degree. Census tracts with higher percentages of Blacks and Asian were less likely to complain than census tracts with lower proportions of residents that identify as Black and Asian. However, census tracts with higher percentages of Hispanic residents were more likely to report regardless of whether they had a TRI facility or not. Educational attainment was also found to be statistically associated with complaints on toxic chemical releases. On average, census tracts with a higher proportion of high school and college graduates were less likely to report toxic chemical emissions (Table 13). On average, the census tracts with multiple complaints had 2% fewer females with college degrees than census tracts with no complaints. Overall, education and race/ethnicity seem to be the most influential on complaints to air toxics.

Table 11: Spearman Correlation Coefficient for Number of air pollution complaints and Socio-Demographic Variables (N=676)

Spearman's Correlation Coefficients, P Values N = 676													
	Air pollution complaints	Median HH income	HS Diploma	Undergraduate Degree	Graduate Degree	White	Non-White	Black	Hispanic	Asian	Below Poverty Line	Public Assistance	Vacant Housing %
Air pollution complaint	1.0												
Median HH income	-0.06 0.11	1.0											
HS Diploma	0.15 0.0001	-0.33 <.0001	1.0										
Undergraduate Degree	-0.13 0.0007	0.73 <.0001	-0.65 <.0001	1.0									
Graduate Degree	-0.13 0.0010	0.62 <.0001	-0.60 <.0001	0.84 <.0001	1.0								
White	0.09 0.02	0.65 <.0001	0.024 0.54	0.35 <.0001	0.30 <.0001	1.0							
Non-White	-0.10 0.009	-0.67 <.0001	-0.008 0.83	-0.37 <.0001	-0.32 <.0001	-1.0 <.0001	1.0						
Black	-0.09 0.02	-0.67 <.0001	0.11 0.003	-0.40 <.0001	-0.34 <.0001	-0.94 <.0001	0.94 <.0001	1.0					
Hispanic	0.08 0.03	-0.09 0.01	-0.20 <.0001	0.04 0.32	-0.057 0.14	-0.18 <.0001	0.15 0.0002	-0.05 0.21	1.0				
Asian	-0.14 0.0007	0.18 <.0001	-0.47 <.0001	0.37 <.0001	0.29 <.0001	-0.09 0.03	0.07 0.09	-0.12 0.005	0.37 <.0001	1.0			
Below Poverty Line	0.07 0.08	-0.90 <.0001	0.19 <.0001	-0.62 <.0001	-0.48 <.0001	-0.66 <.0001	0.67 <.0001	0.64 <.0001	0.16 <.0001	-0.12 0.005	1.0		
Public Assistance	0.011 0.77	-0.76 <.0001	0.32 <.0001	-0.67 <.0001	-0.54 <.0001	-0.61 <.0001	0.63 <.0001	0.65 <.0001	-0.07 0.07	-0.25 <.0001	0.74 <.0001	1.0	
Vacant Housing %	0.14 0.005	-0.63 <.0001	0.12 0.002	-0.39 <.0001	-0.27 <.0001	-0.27 <.0001	0.28 <.0001	0.31 <.0001	0.03 0.42	-0.22 <.0001	0.63 <.0001	0.40 <.0001	1.0

Table 12: Bivariate Ordinal Logistic Regression of the relation between # of complaints to Air Toxics and socio-demographic variables. (N=676)

Census Tract Characteristics (Predictor)	Multiple Complaints N=117 (17.3%)	Single Complaint N=169 (25%)	No Complaints N=390 (57.7%)	BETA ESTIMATE	OR (95% CI)	P value[2]
TRI Facility **Present (1)** **Absent (0)**	54 (46.2) 63 (54.0)	43 (25.4) 126 (18.6)	38 (9.7) 352 (90.3)	0.794	4.892 (3.392, 7.055) 1.000	<.0001
Median Household Income **Median (IQR)**	46742 (38628, 57974)	47261 (36935, 62757)	49478 (37072, 65342)	0.0000006	1.0 (1.0, 1.0)	0.11
% of population White, **Median (IQR)**	71.5 (39.5 – 86.9)	65.3 (30.1, 85.5)	65.4 (17.1 – 86.0)	-0.00625	0.994 (0.989, 0.998)	0.0076
% of population non-White **Median (IQR)**	27.1 (11.6 – 58.1)	32.0 (13.3, 68.3)	31.4 (13.1 – 79.9)	0.00615	1.006 (1.002, 1.011)	0.009
% of population Black **Median (IQR)**	14.3 (6.0 - 34.2)	17.5 (5.7, 47.8)	17.6 (6.6 – 71.8)	0.00749	1.008 (1.003, 1.012)	0.0016
% of population Hispanic **Median (IQR)**	3.7 (2.0 – 7.9)	3.8 (1.7, 10.9)	2.9 (1.5 – 6.0)	-0.0233	0.977 (0.962, 0.992)	0.0029
% of population Asian **Median (IQR)**	0.9 (0.2 – 2.4)	1.6 (0.4, 3.8)	1.8 (0.5 – 4.2)	0.0493	1.051 (1.006, 1.097)	0.0263
% of Female HS diploma **Median (IQR)**	9.6 (7.3 – 11.5)	9.0 (6.4, 11.0)	8.3 (6.0, 10.7)	0.097	0.907 (0.864, 0.953)	<0.0001
% of Female Undergrad degree **Median (IQR)**	6.2 (4.1 – 9.5)	7.6 (4.6, 12.2)	8.4 (5.1 – 11.9)	0.0507	1.052(1.019, 1.086)	0.0017
% of Female Grad degree **Median (IQR)**	1.8 (1.1 -2.8)	2.1 (1.1, 4.1)	2.4 (1.3 -4.1)	0.0949	1.100 (1.032, 1.172)	0.0035
% of population with income below poverty line **Median (IQR)**	8.3 (5.0, 13.3)	9.1 (4.7, 13.8)	7.5 (3.5 – 13.9)	0.0033	1.003 (0.990, 1.017)	0.6170
% of Housing Vacant **Median (IQR)**	5.2 (3.7 – 6.9)	5.2 (3.5, 7.4)	4.2 (2.8 – 6.4)	-0.0185	0.982 (0.950, 1.014)	0.27
% of Households on Pub Assist **Median (IQR)**	2.0 (0.9 – 3.3)	1.5 (0.7, 3.2)	1.5 (0.6 – 3.4)	0.0112	1.011 (0.972, 1.052)	0.5748

Table 13: Multivariate Ordinal Logistic Regression Model of the relation between # of complaints to Air Toxics and socio-demographic variables.

Census Tract Characteristics	Unadjusted OR	Adjusted OR*	P Value

TRI Facility **Present (1)** **Absent (0)**	4.892 (3.392, 7.055) 1.000	4.061 (2.779, 5.935) 1.00	<.0001
Median Household Income	1.000 (1.000, 1.000)	1.000 (1.000, 1.000)	0.54
% of population black	1.008 (1.003, 1.012)	0.991 (0.984, 0.998)	0.0072
% of population Hispanic	0.977 (0.962, 0.992)	1.025 (1.005, 1.046)	0.014
% of population Asian	1.051 (1.006, 1.097)	0.928 (0.880, 0.979)	0.0061
% of population female HS diploma	0.907 (0.864, 0.953)	1.071 (0.993, 1.155)	0.074
% of population female undergrad degree	1.052(1.019, 1.086)	1.045 (1.001, 1.100)	0.05

*Adjusted model included the following covariates: Toxic Release Inventory Facility Present/Absent in the census tract, Median Household Income, % of population black, % of population Hispanic, % of population Asian, % of population female with an high school diploma and % of population female with an undergraduate degree

4.5 Resolution of complaints to air toxic emissions

The only socio-demographic variable statistically significantly associated with the resolution time of complaint was Hispanic composition. The time it took to resolve a complaint to toxic chemical emissions was associated with the percentage of Hispanic residents in a census tract (Table 11). As the percentage of Hispanic residents increased in a census tract the time it took to resolve an environmental complaint to air toxics increased (OR = 1.025, P = 0.01) controlling for Toxic Release Inventory Facility Present/Absent in the census tract, Median Household Income, % of population Black, % of population Hispanic and % of population female with an undergraduate degree.

Table 14: Bivariate Ordinal Logistic Regression of the relation between time to resolution of air toxic complaint and socio-demographic variables. (N=286)

Census Tract Characteristics (Predictor)	>30 days N=66 (23.1%)	8-30 days N=46 (16.1%)	2-7 days N= 55 (19.2%)	1 day 119 (41.6%)	B ESTIMATE	OR (95% CI)	P value[2]
TRI Facility **Present (1)** **Absent (0)**	28 (42.4) 38 (57.6)	16 (34.8) 30 (65.2)	24 (43.6) 31 (56.4)	29 (24.4) 90 (75.6)	-0.2858	1.771 (1.133, 2.769) 1.000	0.012
Median Household Income **Median (IQR)**	53158 (40077, 62180)	47012 (39167, 55712)	46742 (37595, 58287)	49514 (35401, 61276)	-0.0000052	1.0 (1.0, 1.0)	0.31
% of population White, **Median (IQR)**	71.4 (39.5 – 85.2)	67.0 (35.2, 88.4)	68.5 (40.7, 86.0)	70.1 (18.6, 87.1)	-0.00404	0.996 (0.989, 1.003)	0.2492
% of population non-White **Median (IQR)**	28.0 (13.5 – 58.1)	30.1 (11.1, 62.2)	29.6 (13.1, 56.9)	28.5 (11.5 – 76.7)	0.00419	1.004 (0.997, 1.011)	0.2354
% of population Black **Median (IQR)**	13.6 (4.3 - 31.0)	19.3 (6.5, 43.9)	12.8 (6.1, 36.8)	17.1 (6.1, 62.3)	0.00945	1.009 (1.002, 1.017)	0.012
% of population Hispanic **Median (IQR)**	5.4 (2.6 – 13.8)	3.6 (1.7, 7.9)	4.2 (2.4, 11.4)	2.9 (1.3 – 5.9)	-0.0308	0.970 (0.950, 0.990)	0.0032
% of population Asian **Median (IQR)**	2.0 (0.2 – 4.7)	0.9 (0.2, 2.0)	1.3 (0.4, 3.6)	1.2 (0.2 – 3.0)	-0.0433	0.958 (0.901, 1.018)	0.1624
% of Female HS diploma **Median (IQR)**	8.8 (6.7 – 10.9)	9.6 (6.9, 11.3)	9.6 (6.8, 11.4)	9.3 (6.4, 11.7)	0.0165	1.017 (0.950, 1.088)	0.6343
% of Female Undergrad degree **Median (IQR)**	7.4 (4.5 – 11.3)	8.0 (4.7, 10.1)	7.4 (4.7, 10.5)	6.3 (3.7 – 11.5)	-0.0107	0.989 (0.944, 1.037)	0.6558
% of Female Grad degree **Median (IQR)**	1.9 (1.2 -3.4)	2.0 (1.4, 3.2)	1.9 (1.1, 3.3)	2.0 (0.8 - 3.9)	0.0560	1.058 (0.959, 1.166)	0.2615
% of population with income below poverty line **Median (IQR)**	8.5 (4.9, 12.6)	8.7 (5.2, 12.3)	7.1 (4.4, 13.0)	9.8 (4.7 – 15.1)	0.0175	1.018 (0.994, 1.041)	0.1367

% of Housing Vacant Median (IQR)	4.9 (3.3 – 6.4)	4.8 (3.5, 6.6)	5.6 (3.0, 7.3)	5.5 (3.8 – 7.8)	0.0659	1.068 (1.002, 1.141)	0.05
% of Households on Pub Assist Median (IQR)	1.3 (0.6 – 2.6)	1.8 (0.8, 3.0)	1.9 (0.8, 3.5)	2.0 (0.8 – 4.2)	0.0959	1.101 (1.022, 1.186)	0.0115

Table 15: Multivariate Ordinal Logistic Regression Model of the relation between time to resolution of air toxic complaint and socio-demographic variables.

Census Tract Characteristics	Unadjusted OR	Adjusted OR*	P Value
TRI Facility			
Present (1)	1.771 (1.133, 2.769)	1.723 (1.100, 2.732)	0.02
Absent (0)	1.000	1.00	
Median Household Income	1.000 (1.000, 1.000)	1.000 (1.000, 1.000)	0.78
% of population Black	1.009 (1.002, 1.017)	0.994 (0.985, 1.003)	0.20
% of population Hispanic	0.970 (0.950, 0.990)	1.031 (1.010, 1.054)	0.0101
% of population female undergrad degree	0.989 (0.944, 1.037)	1.007 (0.941, 1.078)	0.83

[H]Adjusted model included the following covariates: Toxic Release Inventory Facility Present/Absent in the census tract, Median Household Income, % of population Black, % of population Hispanic and % of population female with an undergraduate degree

Discussion

Using 2000 census data, we found evidence of racial and socio-demographic disparities in the burden of TRI facilities and chemical emissions in the Atlanta MSA. We used logistic regression to evaluate the association between a census tract with a TRI facility and SES and race/ethnicity at the census-tract level. The results of multivariate logistic regression models revealed that there are higher percentages of African American residents in census tracts that have TRI facilities than census tracts that do not. This may be evidence of spatial disparities in the distribution of facilities that release air toxic emissions in the Atlanta MSA. We found that 33% of the population was non-White in census tracts that had TRI facilities and 28% were non-white in census tracts that did not have TRI facilities. We observed a similar trend for toxic chemicals emitted suggesting that more blacks and Hispanics were burdened by and potentially exposed to emissions from TRI facilities than were Whites. Percentage of female college graduates and percentage of blacks were the only statistically significant variables that showed a negative relationship- as percentage of college graduates increased in each census tract, the odds of that census tract having a TRI facility decreased. Additionally, as the percentage of blacks increased in each census tract, the odds of that census tract having a TRI facility increased. In addition, we used linear regression to evaluate the association between the number of TRI emissions and amount of chemical emissions in pounds in each census tract and corresponding SES and race/ethnicity. There was only one variable, percentage of females with college degree, were we observed a negative and statistically significant association with the amount of chemical emissions in pounds. As the number of individuals with low SES increased, the number of TRI facilities at the census-tract level increased. We observed the opposite relationship between percentage of Whites and the number of TRI facilities. These results indicate the role that race/ethnicity and socioeconomic composition play in whether or census tract will have a TRI facility and how many chemicals are emitted as an indication of burden disparities for low-SES populations as well as non-Whites in the Atlanta MSA.

These results are similar to results presented in the environmental justice literature. We found that in the Atlanta MSA education attainment and racial/ethnic composition are the more important predictors of exposure to TRI facilities and emissions. A cross-sectional study conducted by Mohai et al. (2009) found that African Americans and respondents at lower educational levels and lower income levels were significantly more likely to live within a mile of a polluting facility. Racial disparities were especially pronounced in metropolitan areas of the Midwest and West and in suburban areas of the South. Additionally, Wilson et al. (2009) found a direct association between presence of TRI facilities in census tracts/blocks and high percentage non-White and an inverse association between number of TRI facilities and high SES. Toxic Waste and Race in America demonstrated that extensive racial and socioeconomic disparities persist in the distribution of hazardous waste facilities and unhealthy land uses (Mohai & Bunyan, 1987). Furthermore, Hutch et al. (2011) found neighborhoods with hazardous waste facilities are 56% people of color whereas neighborhoods without hazardous waste facilities are 30% people of color. In metropolitan areas, where eighty percent of hazardous waste facilities are located, neighborhoods with these facilities are approximately 60% minority.

Since 1987, there have been numerous reports and studies that reiterated the findings of Toxic Waste and Race in America and the subsequent update. These results present a case for exploring the cumulative burden and impact of all noxious facilities in metro Atlanta and potential linkages to environmental health disparities.

We also found evidence that regulation of TRI facilities may differ according to local demography. Minority communities were less likely to report TRI facility emissions even though they are the population that is burdened by the effects. Specifically, census tracts with higher African Americans and Asians were less likely to report a toxic chemical emission. Census tracts with higher percentages of Hispanic residents had more complaints than other minorities. Furthermore, complaints from census tracts with high percentages of Hispanic residents take longer to be resolved. It's possible that residents in census tracts with higher Hispanic populations complain more often because the complaints take longer to be resolved, which could trigger re-complaints concerning an issue.

Although no studies have investigated whether disparities exist for minorities and populations of low SES, there have been a few studies that have looked at other means of regulation. Hird (1993) studied Superfund sites at the national and county level and concluded the wealthy were more likely to be represented in the Superfund cleanup program. It was noted in this study that minorities are more likely to live in close proximity to hazardous sites, however these sites are less likely to be listed on the NPL (Hird, 1993). Our study shows that even though minorities and people of lower SES experience the largest burden from TRI facilities and emissions, they are less likely to report issues. More specifically, in census tracts with large Hispanic populations complaints take longer to be resolved than other racial groups.

Limitations

This study has some limitations. We used 2006-2011 TRI data and 2000 census data, which could have introduced some burden misclassification. Additionally, we looked at the cumulative effect of TRI facility distribution and emissions over a six-year period, we did not look at changes over time. Therefore, these results provide only a snapshot of burden disparities of TRI facilities in the Atlanta MSA. It is important to look retrospectively at both changes in the TRI distribution over time and changes in population socio-demographic characteristics. An additional limitation was the focus on facility location and emissions but not the toxicity of the chemicals emitted. Previous research has shown that to understand burden and exposure disparities, it is important to examine toxicity of the chemicals emitted from the facilities. In addition, we did not look to see if the exposures were related to any adverse health outcomes in the study area. Looking at disease outcomes can let us know what effect the exposures are having on the health of the population. There were also a limited number of variables with which to estimate SES. More specifically, education attainment only available in females. Once taking in consideration the education attainment of all individuals living in the census tract it could change the results dramatically. However, female education attainment is a good proxy for the education attainment of the entire census tract.

VII Conclusion

This study has shown that there are burden disparities in the distribution of TRI facilities and air toxic emissions in the Atlanta MSA census tract levels, across varying levels of racial/ethnic composition and SES. More specifically, census tracts with lower educational attainment and higher proportions of Hispanics and Blacks are faced with the greatest burden. Even with a few methodological limitations, this study found statistically significant associations between census tract TRI distribution and Hispanic and Black composition and education. Additionally, air toxic emissions were statistically significantly associated with percent of female college graduates in a census tract. There is also evidence of regulation differences of TRI facilities and air toxic emissions in the Atlanta MSA. Complaints are less likely to come from minority groups even though they face largest burden. There is also evidence that Hispanic populations complaints to air toxic emissions are resolved differently than any other racial group.

This study's findings are unique because it is one of the first to look at exposure disparities in metropolitan Atlanta. It is also one of the first to show minority and/or low SES populations are less likely to report environmental issues related to air quality. Additionally, when Hispanic populations complain or report environmental issues they are resolved at a much lower rate compared to other ethnic groups.

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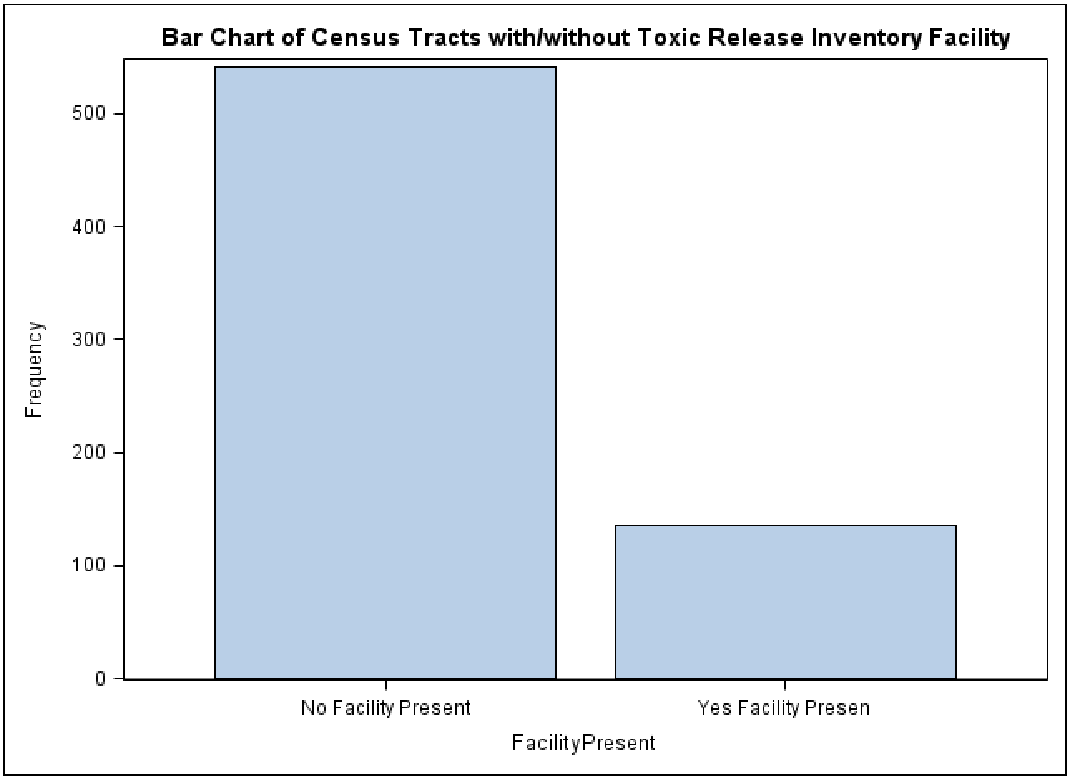
Appendix A: Frequency TRI facilities in the Atlanta MSA

Figure 4: Frequency of TRI facilities in Atlanta MSA census tracts



Appendix B: Scatterplots of emissions and socio-demographics

Figure 5: Scatterplot and fitted regression line for Percent of Population Female with Undergraduate Degree and the Total amount of air toxic chemicals emitted in a given census tract

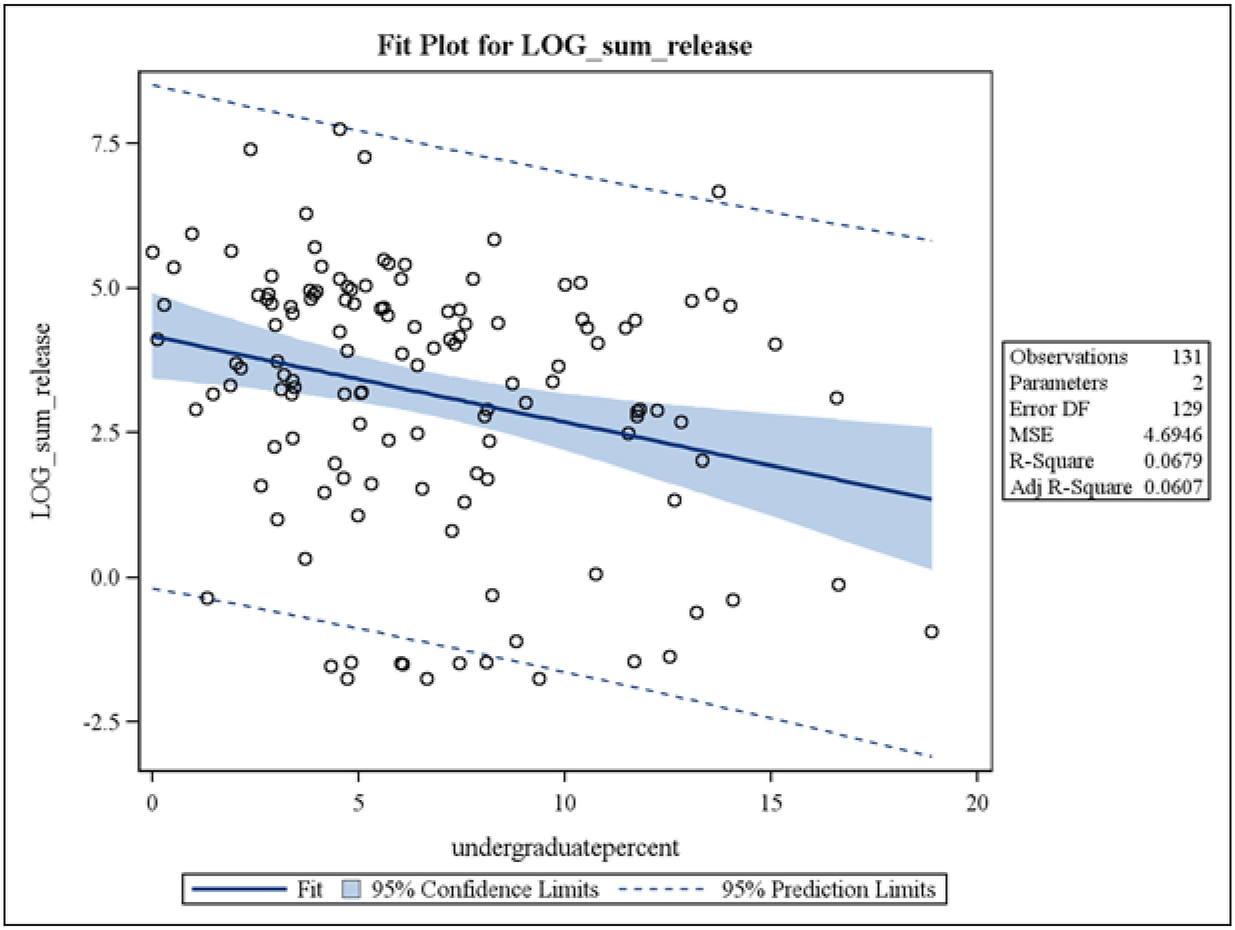


Figure 6: Scatterplot and fitted regression line for Percent of Population Female with Graduate/Professional Degree and the Total amount of air toxic chemicals emitted in a given census tract

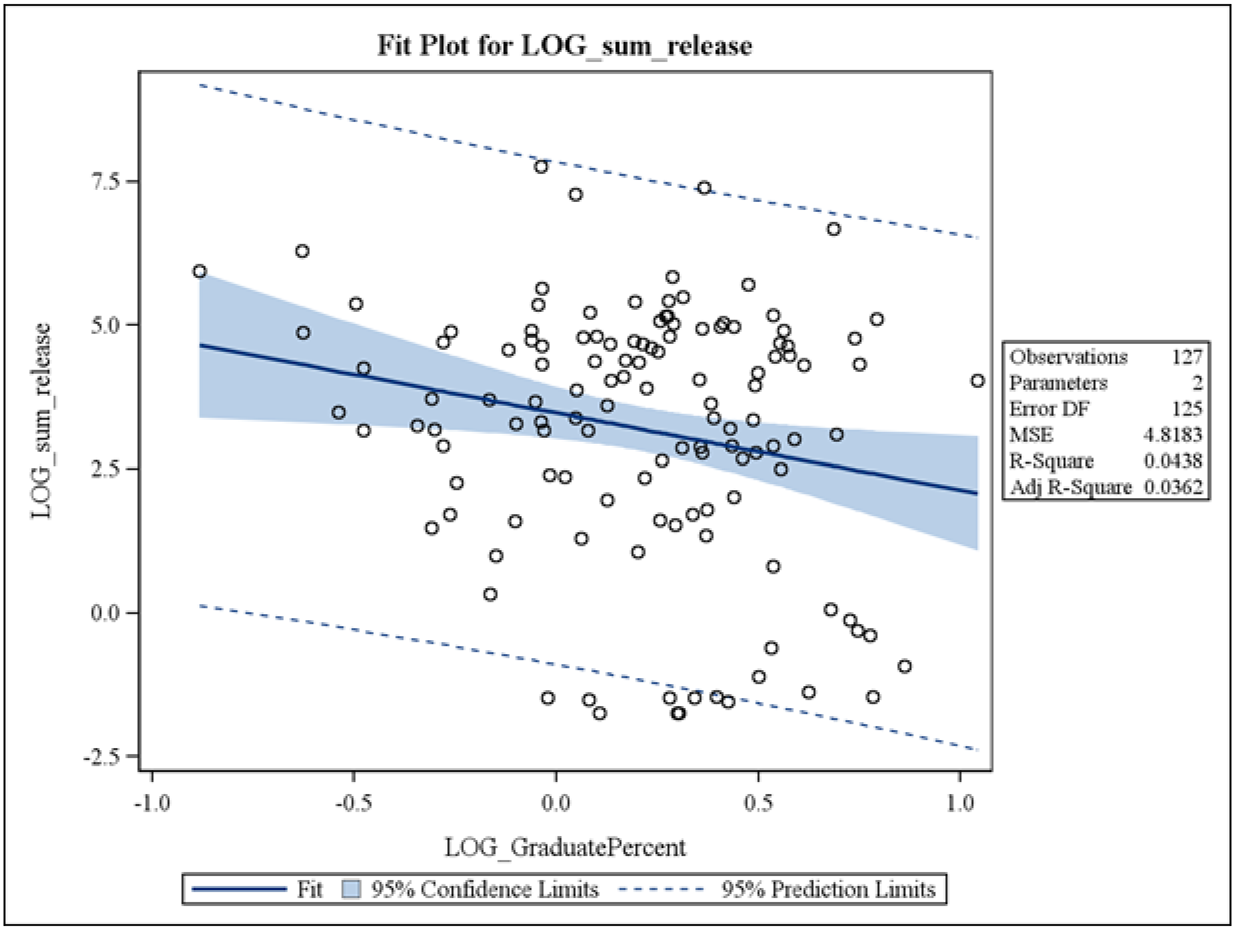


Figure 7: Scatterplot and fitted regression line for Percent of Population Female with Undergraduate Degree and the average amount of air toxic chemicals emitted per emission in a given census tract

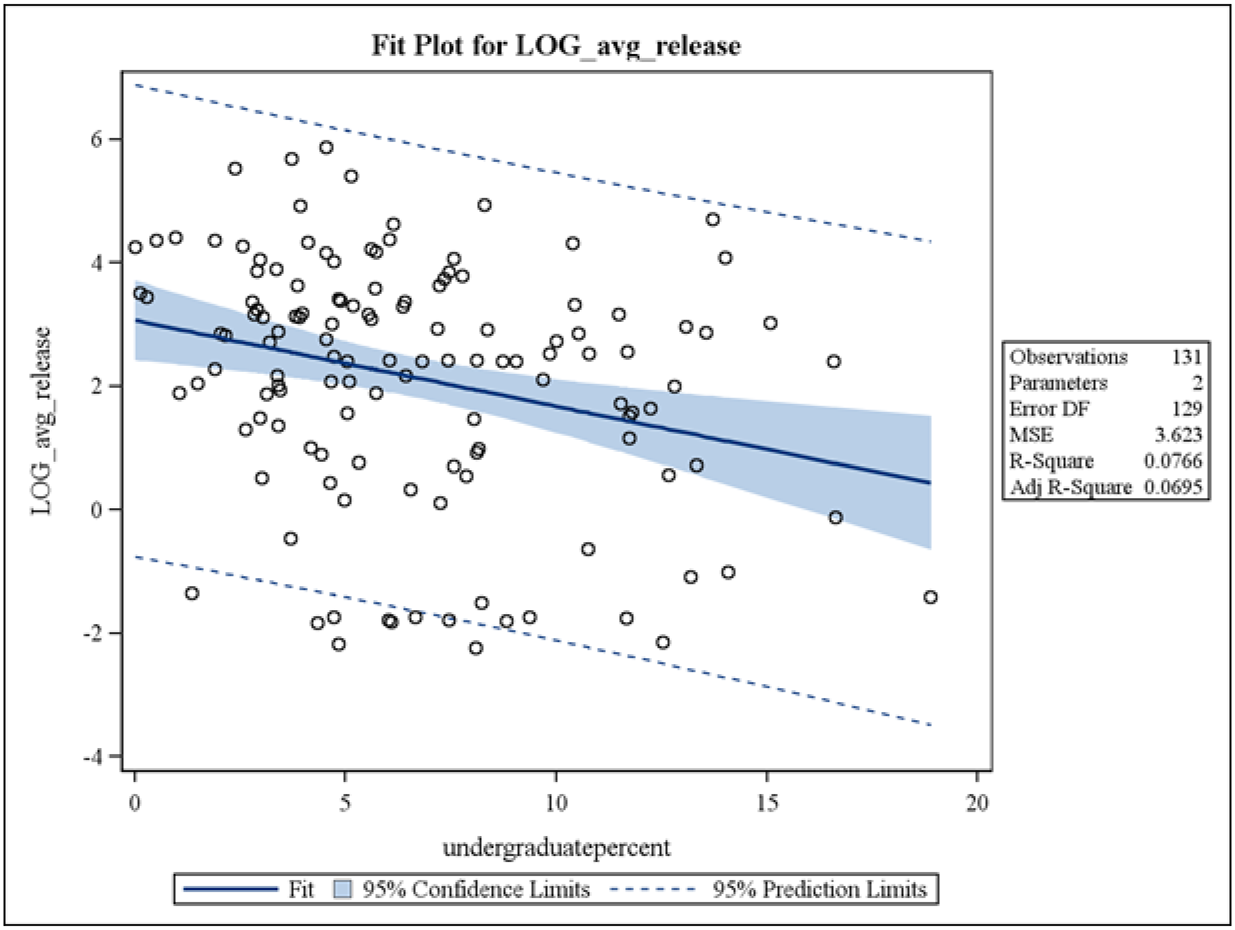
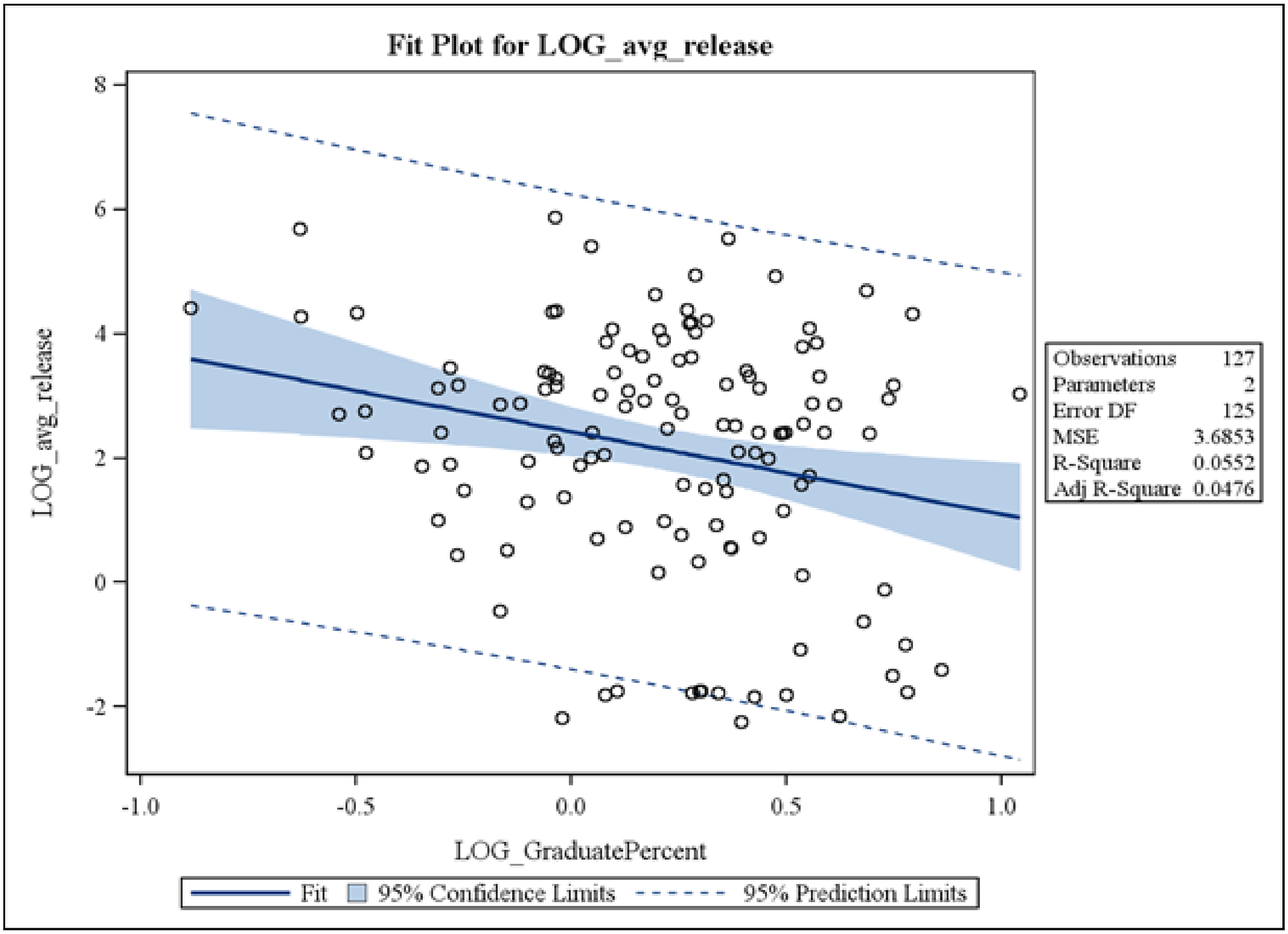


Figure 8: Scatterplot and fitted regression line for Percent of Population Female with Graduate Degree and the average amount of air toxic chemicals emitted per emission in a given census tract



Appendix C: Box and Whisker facility distribution and socio-demographics

Figure 9: Box and Whisker Plot of Percent of Population Black by Presence/Absence of TRI facility in Census Tract

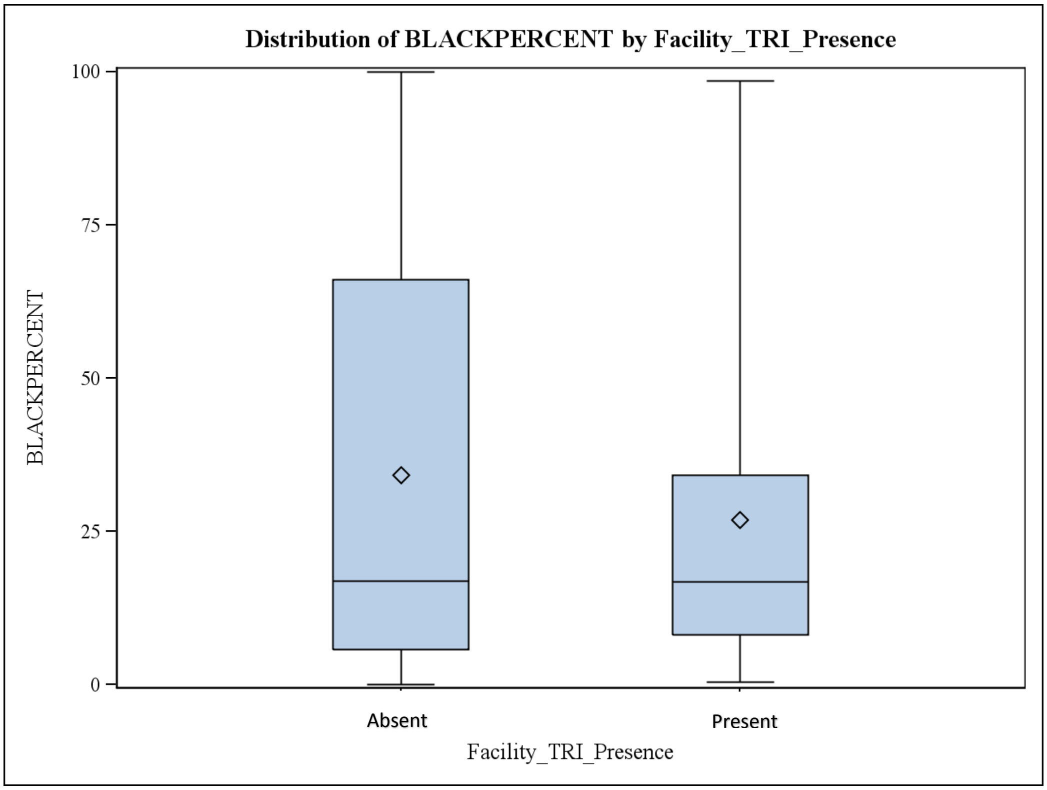


Figure 10: Box and Whisker Plot of Percent of Population Female with undergraduate degree by Presence/Absence of TRI facility in Census Tract

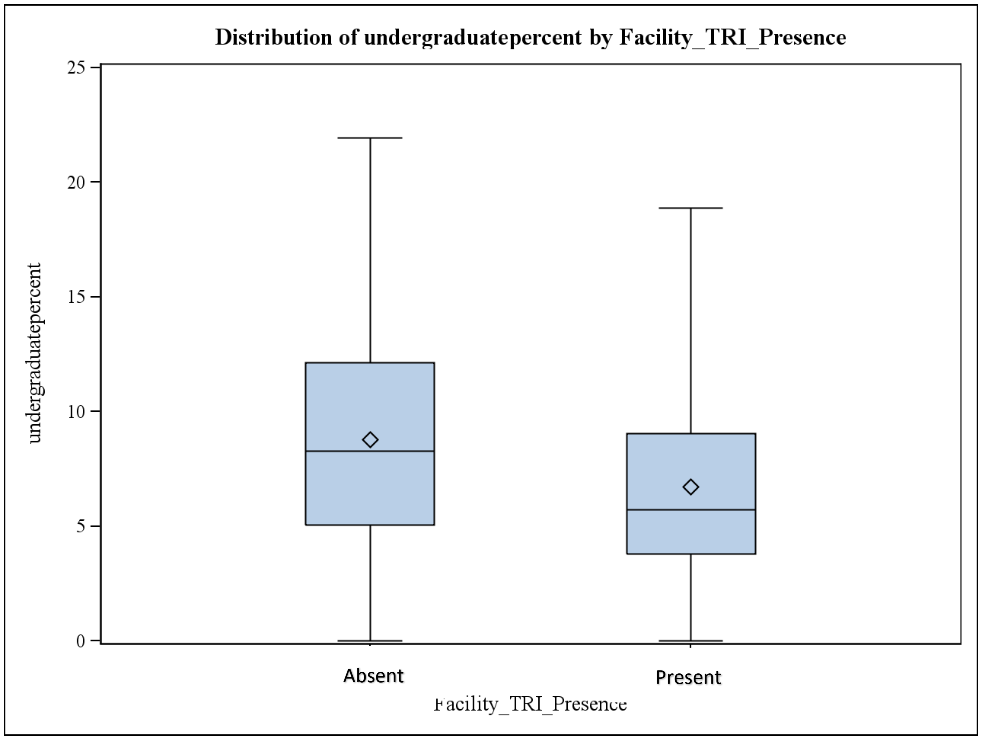
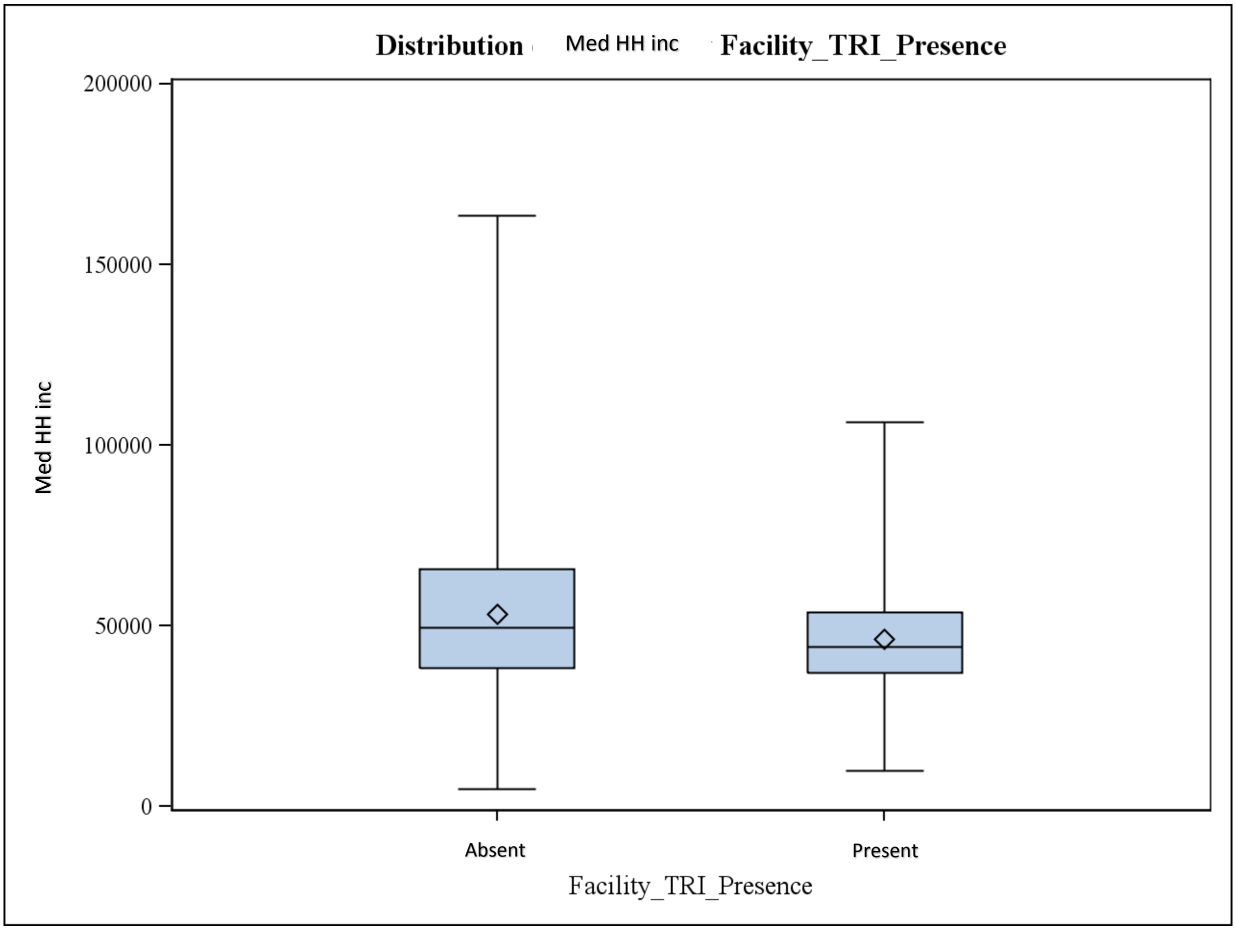


Figure 11: Box and Whisker Plot of median household income by Presence/Absence of TRI facility in Census Tract



Appendix D: Box and Whisker plots complaints and socio-demographics

Figure 12: Box and Whisker Plot of percent of population black by number of complaints to air toxics in Census Tract

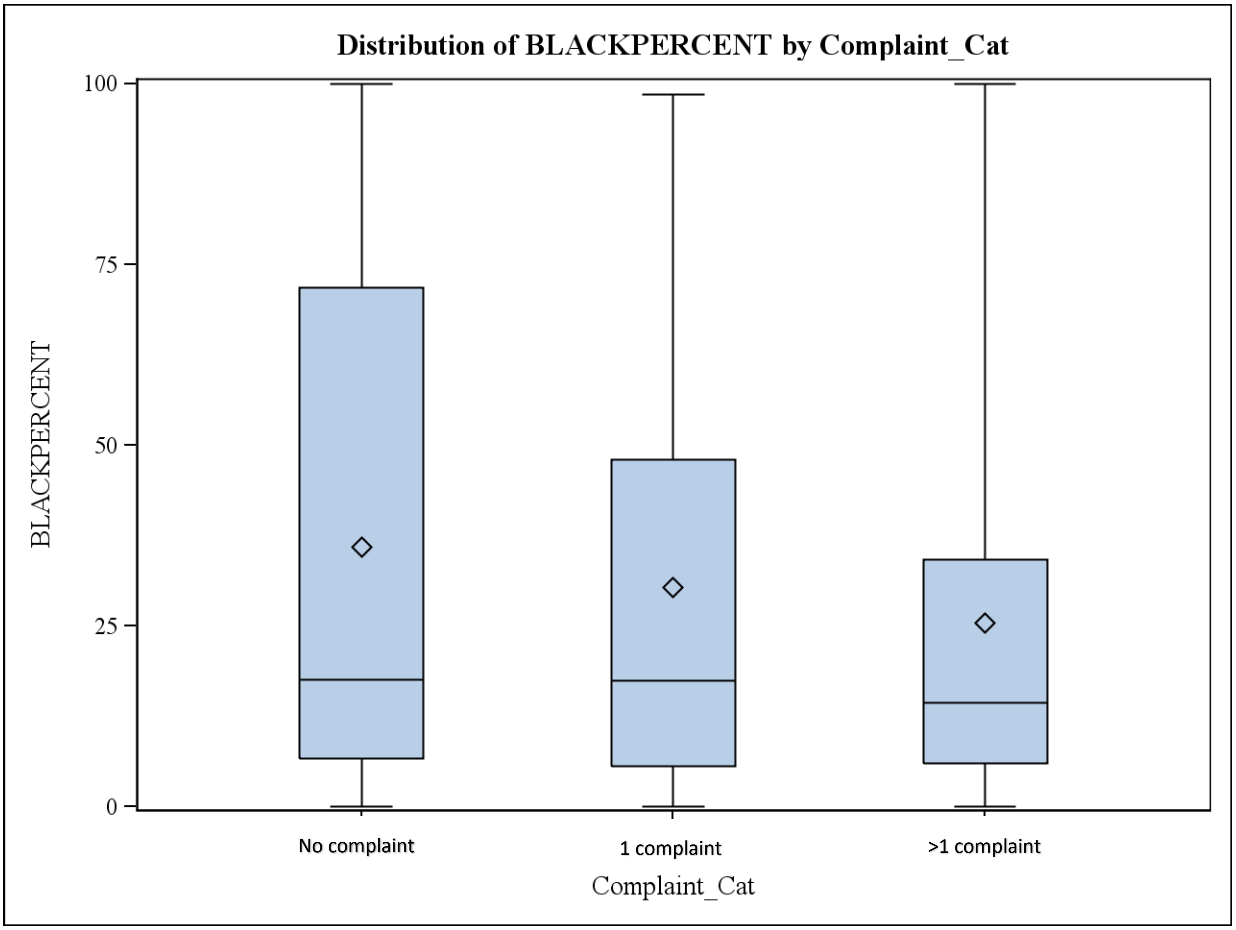


Figure 13: Box and Whisker Plot of percent of population Hispanic by number of complaints to air toxics in Census Tract

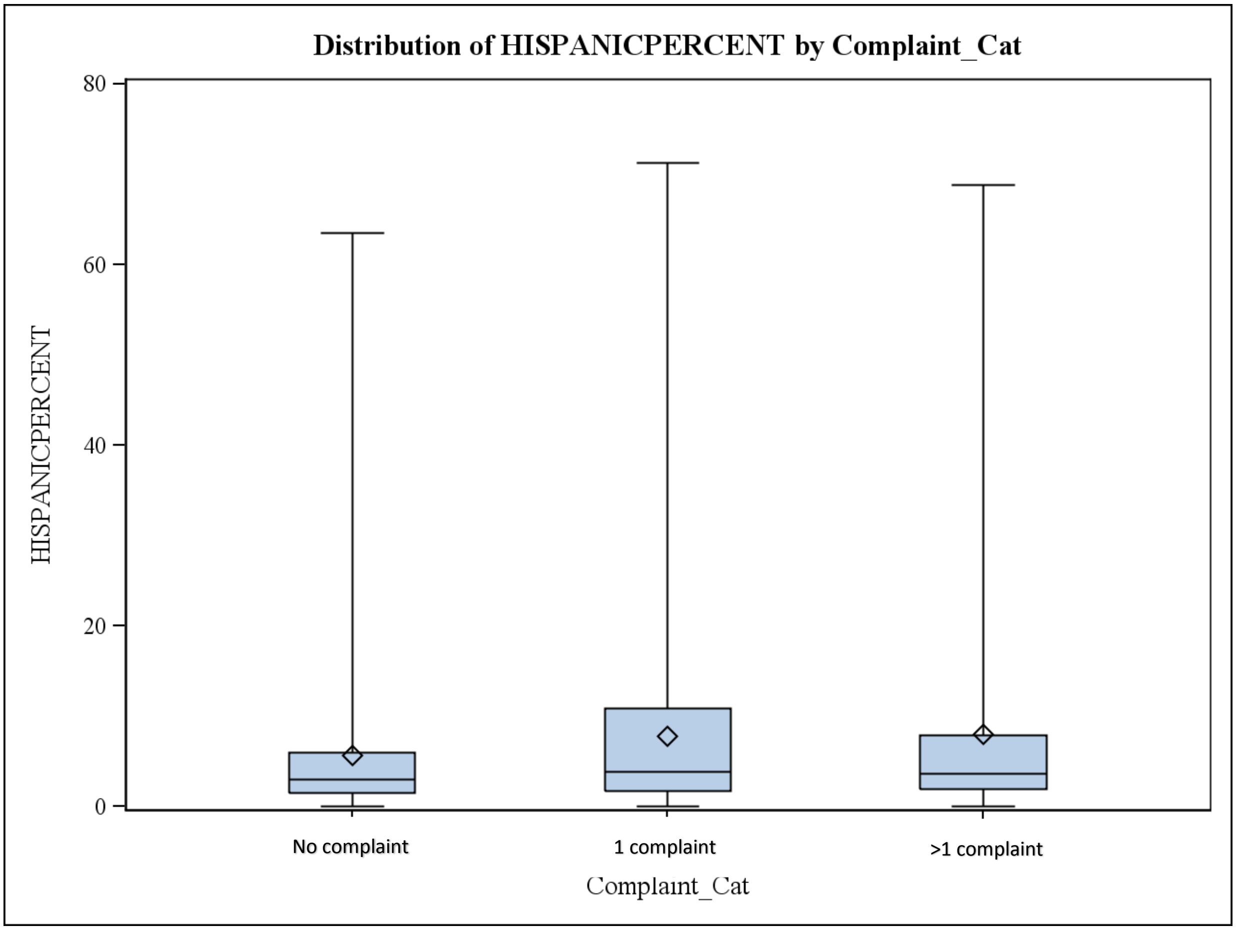


Figure 14: Box and Whisker Plot of percent of population Asian by number of complaints to air toxics in Census Tract

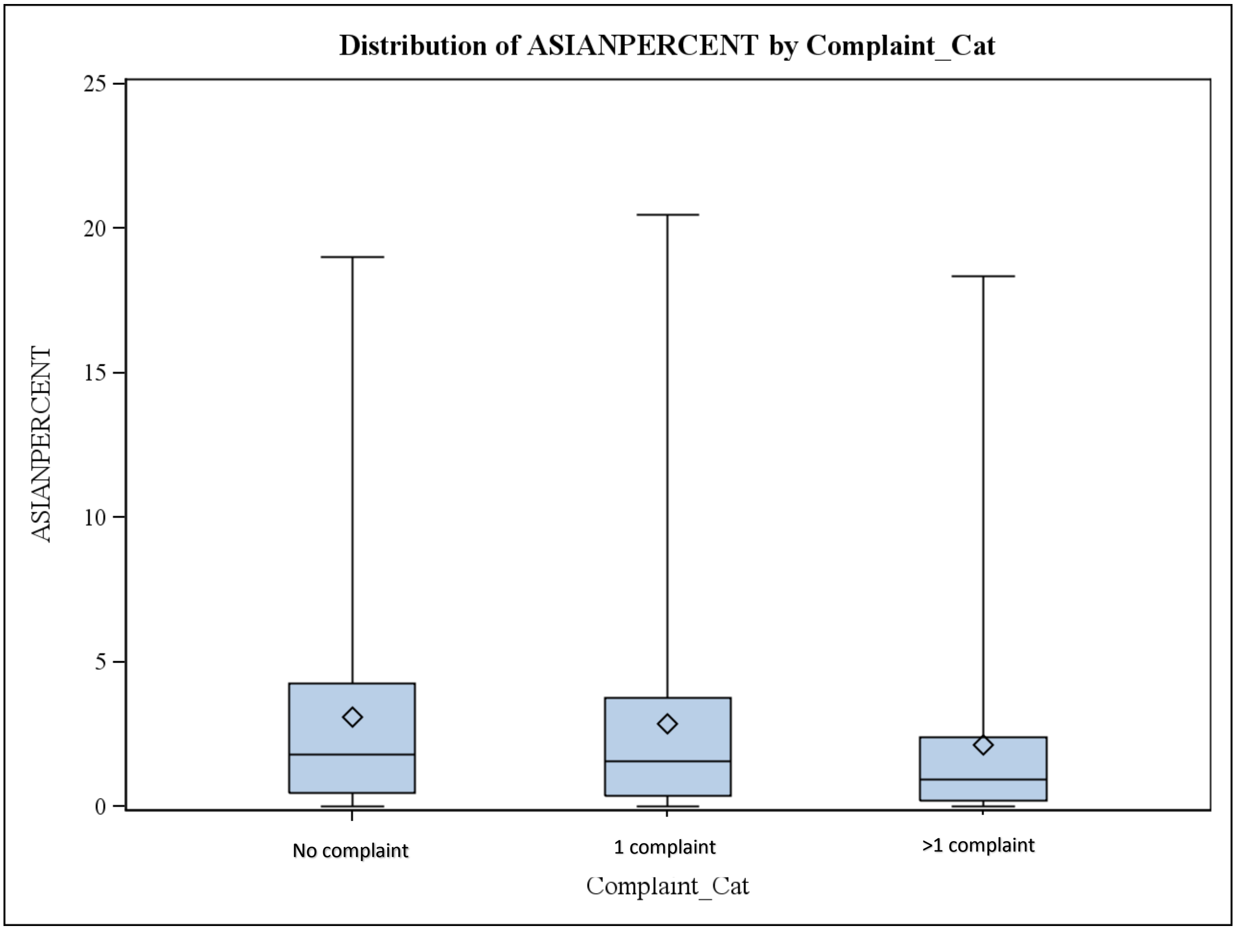


Figure 15: Box and Whisker Plot of percent of population Female with Undergraduate degree by number of complaints to air toxics in Census Tract

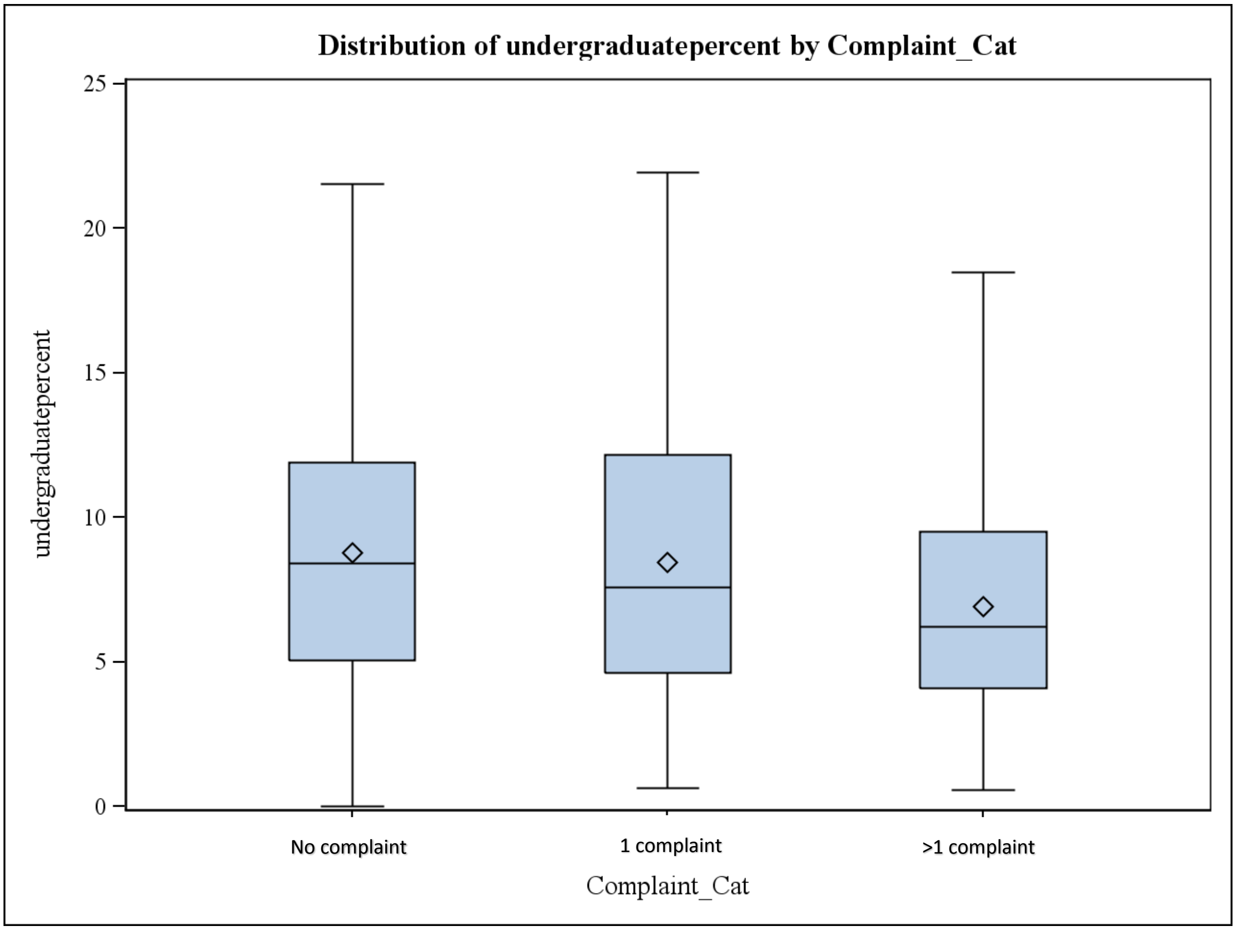
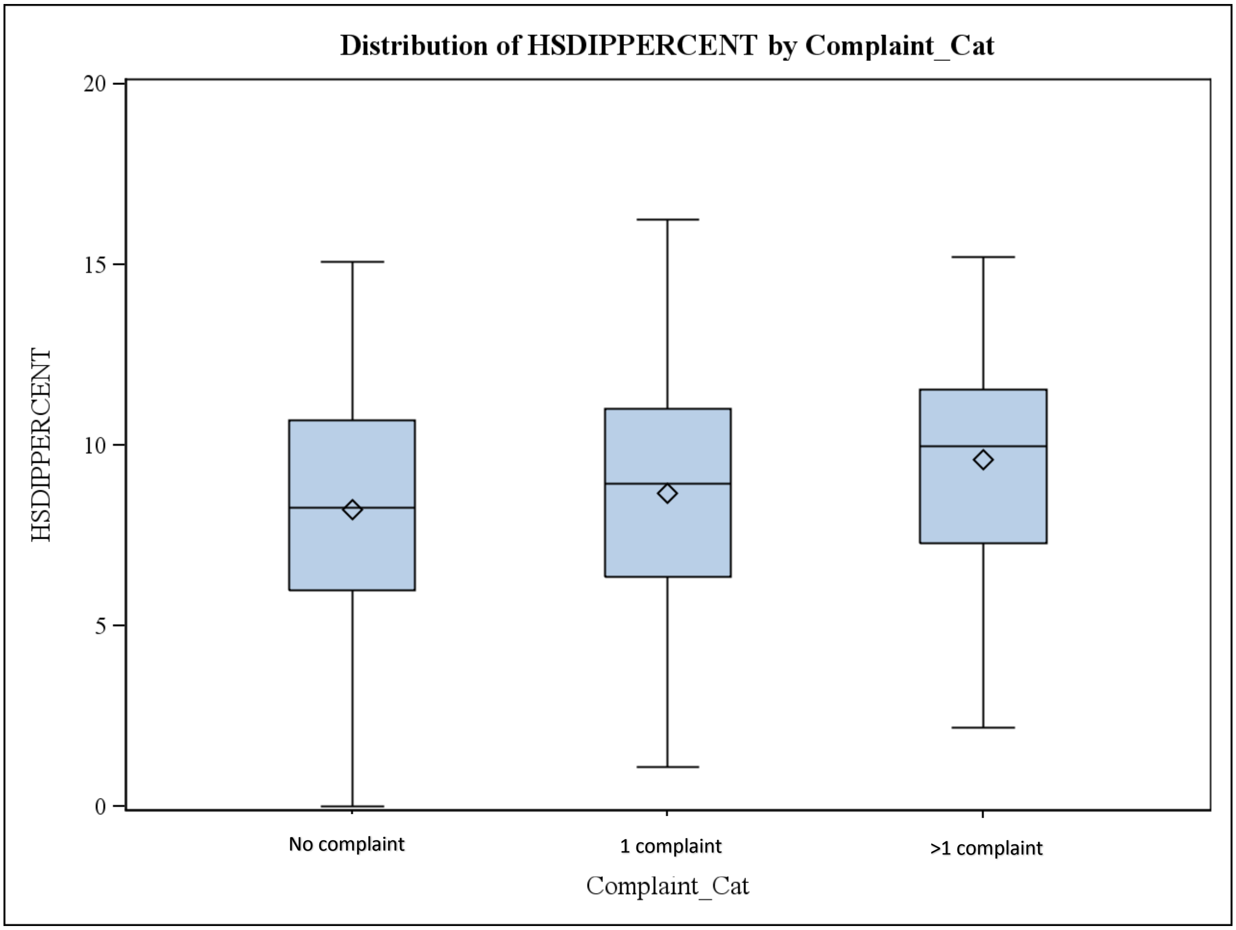


Figure 16: Box and Whisker Plot of percent of population Female with high school diploma by number of complaints to air toxics in Census Tract



Appendix E: Box and Whisker plots resolution time (days) and socio-demographics

Figure 17: Box and Whisker Plot of percent of population black by number of days it took to resolve complaint in Census Tract

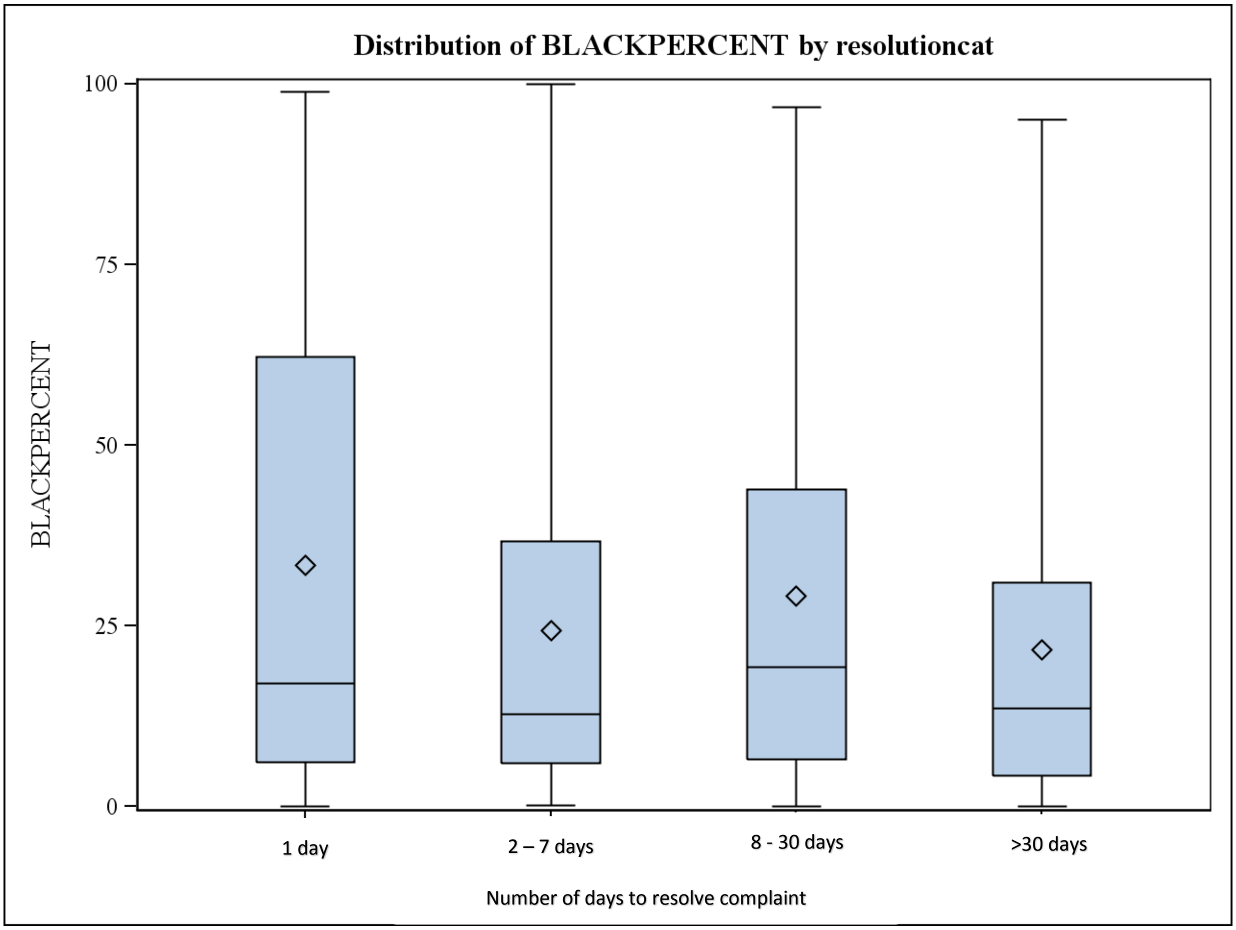


Figure 18: Box and Whisker Plot of percent of population Hispanic by number of days it took to resolve complaint in Census Tract