ENVIRONMENTAL (IN)JUSTICE AND UNEQUAL BURDEN: RACE, INCOME, AND SOLID WASTE SITES IN HOUSTON

by

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ABSTRACT

ENVIRONMENTAL (IN)JUSTICE AND UNEQUAL BURDEN: RACE, INCOME, AND SOLID WASTE SITES IN HOUSTON

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Since the 1980s, the environmental justice (EJ) movement, academics, and advocates have raised much awareness for EJ issues and concerns. Many EJ studies have found that environmental burdens such as waste sites, polluting industries, and other locally unwanted land uses are disproportionately located in low-income communities and minority communities. The goal of this study was to examine the location of Houston's municipal solid waste landfills (MSWLs) in relation to community race/ethnicity and income. The Houston Metropolitan Statistical Area (MSA) was the chosen study area based on prior EJ study findings and concerns. Data for MSWLs was acquired from Texas Commission on Environmental Quality (TCEQ) online databases. Data for racial/ethnic and income characteristics was acquired from the U.S. Census Bureau online databases. ArcGIS software was used to manage the data and analyze the location of the Houston MSA's MSWLs and the racial/ethnic and income characteristics of nearby communities. The results of the analysis suggest that MSWLs in the Houston MSA are located in predominantly Hispanic/Latino communities, Black/African American communities, non-Hispanic White communities, lower-income and middle-income communities. Many communities across the nation endure an unequal burden from living near waste sites. There is significant importance in further study of the populations that live near MSWLs for both environmental justice concerns and public health concerns. Although state and federal environmental regulations aim to limit pollution, environmental pollution caused by MSWLs cannot be completely eradicated. MSWLs present numerous public health concerns for nearby communities including potential for air, land, and water contamination. There is a need for future research to examine the effects MSWLs have on nearby residents' health and quality of life.

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LIST OF ABBREVIATIONS

ACS	American Community Survey
C&D	Construction and demolition
EJ	Environmental justice
EPA	Environmental Protection Agency
GIS	Geographic Information System
LULU	Locally unwanted land use
MSA	Metropolitan statistical area
MSW	Municipal solid waste
MSWL	Municipal solid waste landfill
TCEQ	Texas Commission on Environmental Quality
TIGER	Topologically integrated geographic encoding and referencing
TSDF	Transfer, storage, and disposal facility

Introduction

The U.S. Environmental Protection Agency (EPA) defines Environmental Justice (EJ) as "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" (2019b). This means that all people have the right to a safe and healthy environment. However, several decades of research have consistently found that hazardous and polluting industries create at-risk environments and burdens that affect the health and well-being of nearby populations (Bullard, 2005; Mohai & Bryant, 1992; Pastor, Sadd, & Morello-Frosch, 2002). While these industries are located all over the nation and affect many populations, they affect some populations unequally. Numerous environmental justice studies have documented that environmental burdens such as incinerators, landfills, hazardous waste facilities, chemical plants, refineries, and other polluting industries are disproportionately located in low-income communities and communities of color (Bullard, 1983, 1994, 2005; Bullard, Mohai, Saha, & Wright, 2007; Mohai & Bryant, 1992; Pastor, Sadd, & Hipp, 2001; UCC, 1987). This disproportionate exposure to environmental pollution and burdens, and the associated risks and impacts highlight the need to study, identify, and address environmental justice issues.

Over the last several decades, waste sites have remained a significant interest for EJ researchers, advocates, and environmental organizations. EJ research has consistently found that waste is not randomly or evenly distributed across place; rather, low-income and minority communities are disproportionately burdened by waste sites and facilities (treatment, storage and disposal facilities, or TSDFs) (Bullard, 1983, 2005; GAO, 1983; Mohai & Bryant, 1992; UCC, 1987). Many prior studies have focused on hazardous waste facilities (TSDFs) and have included landfills in its research and analysis. A landfill is one of several forms of waste disposal used nationwide. Municipal solid waste landfills (MSWLs) are the dumping grounds for public waste – anything disposed of by people, households, or establishments. In the U.S., the average person contributes 4.51 pounds of waste per day, with much of it ending up in MSWLs (U.S. EPA, 2019d). Waste in MSWLs is a mixture of different materials, some of which are innately hazardous to health. MSWLs are vital for both public health and environmental reasons, yet they are a burden to the communities that live nearby. In addition to MSWLs releasing malodors, MSWLs have the potential to pollute the air, land, and water as well as affect public health (Center for Health, Environment & Justice, 2016).

One of the earliest EJ studies to examine solid waste sites and the racial makeup of neighboring communities was conducted in the early 1980s (Bullard, 1983). Robert Bullard, one of the major founders of the environmental justice movement, conducted an influential study (1983) that documented a fifty-year pattern of Houston's siting of solid waste disposal facilities. Bullard (1983) found that Houston's solid waste landfills and incinerators were disproportionately located in predominantly Black communities. Bullard's 1983 study along with other notable national studies (GAO, 1983; UCC, 1987) were pivotal for drawing attention to the distribution of environmental burdens in the U.S. Moreover, these prominent studies prompted further analysis of environmental inequities and burdens and helped create the environmental justice field of study.

Greater Houston has historically consisted of a variety of waste, manufacturing, industrial, and petrochemical companies, which has branded it an area for environmental justice concern and research. The Houston Metropolitan Statistical Area (MSA), also known as Greater Houston, is the fifth-largest metropolitan area in the U.S. and is among the nation's fasting-growing metropolitan areas (Wilder, 2019). The MSA surrounds the City of Houston, the fourth-largest city in the U.S. (U.S. Census Bureau, 2019), and consists of the most racially/ethnically diverse population in the country (Klineberg, 2019). The various industries located in Greater Houston along with the large and diverse population call for continuous EJ research in the growing metropolitan area. Prior EJ studies have examined the Houston area (Bullard, 1983; Been, 1994; GAO, 1995), and this research aims to add to EJ research in Houston by examining current data for the metropolitan area's MSWLs and the racial/ethnic and income characteristics. This research will review significant environmental justice literature and use Geographic Information System (GIS) software to visually represent and analyze the location of Greater Houston's MSWLs and the predominant racial/ethnic and income characteristics of communities that contain MSWLs.

What is solid waste?

First, it is essential to identify the different types of waste discussed in this research. The most general definition of waste is anything that is disposed of in the trash or garbage. The U.S. EPA uses the term "solid waste" to represent something that is waste. Solid waste is defined as "any garbage or refuse, sludge from a wastewater treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, resulting from industrial, commercial, mining, and agricultural operations, and from community activities" (U.S. EPA, 2019a). However, it is important to note that solid waste is not restricted to wastes that are physically solid – numerous solid wastes are semi-solid, liquid, or contain gaseous substance (U.S. EPA, 2019a). Waste management – the collection, processing, transport, and disposal of waste – is a combined effort that involves federal, state, regional, and local organizations.

Most of the waste generated inside homes and institutions is considered non-hazardous. Municipal solid waste (MSW) – commonly known as garbage or trash – is a combination of a city's non-hazardous waste. MSW contains everyday items such as food, yard trimmings, paper material (newspapers, magazines, etc.), product packaging, clothing, wood, glass, plastics, metals, furniture, batteries, and electronics. Contributors of MSW consist of residential waste, and waste from commercial and institutional sites (i.e. businesses, schools, and hospitals) (U.S. EPA, 2018). After MSW is generated, it must be gathered and managed. Common waste management methods are recycling, composting, incineration, and landfill. Almost all of MSW ends up in landfills (U.S. EPA, 2019d). The MSWL is the most common method of waste disposal used nationwide (Center for Health, Environment & Justice, 2016). The U.S. EPA estimates that an MSWL may also receive non-hazardous sludge and non-hazardous industrial waste. In addition, due to landfill regulations determined by the state where it is sited – some MSWLs can also receive municipal wastewater treatment sludge and construction and demolition (C&D) debris (U.S. EPA, 2019c; TCEQ, 2017). Although MSWLs are not recognized as containing hazardous waste, all landfills can contain products and chemicals that threaten the air, land, water, and public health (Center for Health, Environment & Justice, 2016).

In general, waste is identified as hazardous if it has properties that are toxic, reactive, ignitable, or corrosive, and has the potential to cause harm to human health or the environment (U.S. EPA, 2019a). Hazardous waste can be liquid, solid, gas, or sludge, and can contain heavy metals, chemicals, pathogens, or other materials. Hazardous waste is generated from numerous sources or industries such as water treatment systems, farming, manufacturing, laboratories, construction, hospitals, and petroleum and chemical industries. Hazardous waste can also come from common household items such as lead-acid batteries or commercial products (i.e. cleaning fluids, paint, motor oil, or pesticides). Household hazardous waste (HHW) poses a real disposal challenge because it is less regulated than hazardous waste from industries (EPA, 2019c). In the U.S., hazardous waste management is overseen by federal environmental regulations, as well as state divisions of environmental protection (EPA, 2019a). Federal laws and regulations require that special precautions be taken when handling, storing, and disposing hazardous waste in designated facilities. These designated facilities are commonly referred to as hazardous waste sites, or transfer, storage, disposal facilities (TSDFs).

Literature Review

Over the last several decades, research has found that low-income communities and communities of color bear a disproportionate and unjust burden of hosting waste sites and other polluting industries throughout the United States, as well as within states and within cities (Bowen, 2002; Bullard, 1983, 1994, 2005; Bullard, Mohai, Saha, & Wright, 2007; Mohai, 1996; Mohai & Bryant, 1992; Pastor, Sadd, & Hipp, 2001). The racial and socioeconomic disparities associated with the distribution of environmental pollution, burdens, and associated risks from hazardous waste sites (TSDFs), solid waste landfills and incinerators, and other industries prompted the environmental justice movement in the U.S. in the 1980s. Environmental justice and the movement embrace "the principle that all people and communities are entitled to equal protection of environmental and public health laws and regulations" (Bullard, 1996, p. 493). Some of the first cases involving environmental (in)justice were in Texas and North Carolina. In 1979, residents of Northwood Manor, a predominantly African American community in East Houston, opposed the choosing of their community to host a municipal landfill (Bullard, 1993; Mitchell, 1993). The residents formed the Northeast Community Action Group (NECAG) and filed a class action lawsuit disputing "the siting of a waste facility as a violation of civil rights" (Bullard, 1993, p. 325). Although the court noted that the location of the landfill would irreparably harm the community, and the residents presented "significant statistical evidence that indicated a history of locating municipal waste disposal facilities in Houston's African American neighborhoods," the court did not find discrimination in the siting of the landfill (Bullard, 1993, p. 325). The residents were not able to stop the construction of the landfill in their community; however, the case initiated the use of courts as an essential approach for the emerging EJ movement, and it underscored the necessity for examination of waste siting decisions and the associated environmental burdens that were affecting other communities nationwide (Bullard, 1993).

In 1982, one of the momentous events of the EJ movement emerged in Afton, Warren County, North Carolina when local residents challenged the location of a proposed landfill for soil that was contaminated by polychlorinated biphenyls (PCBs) (a known carcinogen) (Bullard, 1994; Mohai & Bryant, 1992). At the time, African Americans comprised 84 percent of Afton's population and Warren County was one North Carolina's poorest areas (Bullard, 1994). The residents disputed that the Afton community was targeted for the PCB landfill because it was minority and poor (Bullard, 1994; Mohai & Bryant, 1992; Taylor, 2014). Many experts argued that location of the landfill presented risks to the quality of the drinking water for neighboring residents (Bullard, 1994, p. 36). Warren County residents, national civil rights leaders, and others participated in nonviolent demonstrations that resulted in hundreds of arrests. Despite the protests, widespread support, and national media attention, the PCB landfill was constructed. Before the 1980s, few national studies had focused on the racial and socioeconomic characteristics of people living near waste sites. The Warren County protests and aftermath sparked interest among scholars and policy-makers. Academics began to emphasize that environmental injustices like Warren County were not infrequent and there was a need for further analysis (Bullard, 1994; Taylor, 2014).

The events in North Carolina initiated the pivotal investigations by the U.S. General Accounting Office (GAO) and the New York-based Commission for Racial

Justice in the 1980s (Mohai & Bryant, 1992). The GAO study of 1983 was one of the first studies to draw attention to the distribution of environmental risks and burdens in the U.S. (Bullard, 1994; Mohai & Bryant, 1992). The investigation found hazardous waste landfill locations in the South to be inequitable with respect to socioeconomics and race, with three of the four major hazardous landfills located in predominantly African American communities (Bullard, 1994; 2005; General Accounting Office, 1983). Findings of the GAO study prompted the United Church of Christ's (UCC) Commission for Racial Justice to administer a national analysis of toxic waste and race. In 1987, the UCC released the landmark report "Toxic Wastes and Race in the United States" – the first national study to examine the location of commercial hazardous waste facilities (treatment, storage and disposal facilities, or TSDFs) (Bullard, 2005; Mohai & Bryant, 1992). Findings documented that there was a significant correlation between race and the location of hazardous waste facilities (TSDFs). An analysis of the location of TSDFs and the demographics in zip codes throughout the country found that although socioeconomic status played an important role in the location of TSDFs, race was the most significant predictor of a person living near hazardous waste sites (Mohai & Bryant, 1992). The report found that three out of every five Hispanic Americans and African Americans, and almost half of all Asian/Pacific Islanders and American Indians lived in communities with toxic waste sites (UCC, 1987).

The findings from pivotal studies in the 1980s validated what EJ activists agreed: minority and low-income communities bear a disproportionate amount of environmental risks (Bullard, 1993; Mohai & Bryant, 1992; UCC, 1987). These studies ignited an influx of research focused on environmental justice, environmental racism, and environmental equity (Anderton et al, 1994; Bullard, 1994; 2005; Mohai & Bryant, 1992; Pastor etc.). According to the U.S. EPA, "Environmental equity refers to the distribution of environmental risks across population groups and to our policy responses to these distributions . . . Environmental equity is an important goal in a democratic society. It involves ensuring that the benefits of environmental protection are available to all communities and an environmental policy-making process that allows the concerns of all communities to be heard, understood, and addressed" (1992, p. 2). Many EJ advocates, academics, and organizations use the terms environmental racism and environmental justice mutually or interchangeably. These concepts are important to define to develop a collective understanding of EJ dialogue. Environmental racism refers to "any policy, practice, or directive that differentially affects or disadvantages (whether intended or unintended) individuals, groups, or communities because of their race or color" (Bullard, 2005, p. 32). Furthermore, Environmental Sociologist, David Pellow, asserts:

> "Environmental racism is a form of environmental inequality (which occurs when a particular social group-not necessarily a racial or ethnic group-is burdened with environmental hazards). From a social movement perspective, environmental racism and inequality are what activists are fighting against" (Pellow, 2002, p. 8).

Sociologist Bunyan Bryant (as cited in Pellow, 2002) explains the significance of environmental justice as follows:

> "Environmental justice . . . refers to those cultural norms and values, rules, regulations, behaviors, policies, and decisions to support sustainable communities where people can interact with confidence that the environment is safe, nurturing, and productive" (Bryant as cited in Pellow, 2002, p. 8).

A significant element of the EJ movement is empirical evidence regarding the disproportionate distribution of waste and other environmental burdens and associated risks. Considerable evidence (GAO, 1983; Bullard, 1983, 1994; Bullard, Mohai, Saha, & Wright, 2007; Mohai & Saha, 2006, 2015; UCC, 1987) has played a key function in drawing public attention to the matters of environmental justice, environmental equity, and environmental racism. Since seminal moments like the Warren County landfill protests, the concentration and location of waste sites in low-income communities and communities of color has fundamentally defined the relationship between waste, class, and race (Bullard, 1993, 1994; Mohai & Bryant, 1992). As one of the main founders of the EJ movement, Robert Bullard has continuously scrutinized the correlation between race, wealth, and environmental quality (1983, 1993, 1994, 2005, 2007, 2012). Among Bullard's literature, the 1983 study "Solid Waste Sites and the Black Houston Community" documented the long-term pattern of Houston's siting of solid waste disposal. A fifty-year (1920s-1970s) historical analysis of Houston's permitted solid waste disposal sites reveal that landfills and incinerators had been used by the city as the main disposal methods, and "were not randomly scattered over the Houston landscape" (Bullard, 1983, p. 273). Bullard found that Houston's solid waste landfills and incinerators were disproportionately located in predominantly Black neighborhoods and near schools. Bullard noted that five of the six municipal landfills (83.3%) permitted in Houston from 1970 to 1978 by the Texas Department of Health were located in predominantly Black neighborhoods (Bullard, 1983, p. 281). Between 1970 and 1980, Blacks made up about 27 percent of Houston's population. Moreover, all five of the city's incinerators were located in minority neighborhoods; four were located in predominantly Black neighborhoods and one was located in a predominantly Hispanic neighborhood (Bullard, 1983). Bullard also discussed significant findings regarding landfill sitings and schools. According to Bullard, the City of Houston permitted ten landfills between 1920 and 1976; all ten were located near predominantly Black schools. Thirteen of the sixteen municipal landfills (77%) permitted by the Texas Department of Health between 1953 and 1978 were sited near predominantly Black schools (Bullard, 1983, 1994). Bullard (1994) discusses that discriminatory practices and Houston's lack of zoning are among the contributing factors for the disproportionate location and operation of waste disposal sites among lower socioeconomic communities and communities of color. Throughout his literature, Bullard has documented how race and place combine to disproportionately affect communities of color (Bullard, 1983, 1994, 2005, 2012).

Some of the earliest EJ studies have been essential for bringing attention to environmental injustices; however, these studies have been contested by some academics. In 1994, research conducted at the Social and Demographic Research Institute (SADRI) at the University of Massachusetts documented findings that opposed conclusions of the UCC report of 1987. The SADRI report used 1980 census data and found that there were "no nationally consistent and statistically significant differences between the racial or ethnic composition of tracts which contain commercial TSDFs and whose which do not" (Anderton, Anderson, Oakes, & Fraser, 1994; p. 229). In addition, no difference was found in the percentages of the population living in low socioeconomic status (SES) in census tracts containing TSDFs and those that did not (Anderton et al., 1994). That same year, Goldman and Fitton (1994) used 1990 census data (rather than 1980 census data) to provide an update to the 1987 UCC study. Their study verified that zip codes hosting one TSDF had more than double the percentage of minorities as zip codes with no TSDFs. In addition, the study found that the concentration of minorities living in zip codes with TSDFs increased between 1980 and 1993 (Goldman & Fitton, 1994).

Twenty years after the 1987 UCC report, the "Toxic Wastes and Race at Twenty: 1987-2007" report indicated key findings were similar or worse than previously found; disproportionately high numbers of people of color still lived in communities hosting hazardous waste sites (Bullard et al., 2007). On average, host neighborhoods had poverty rates 1.5 times greater than non-hosting areas (Bullard et al., 2007). More than half (56%)

of all people in the U.S. who lived within 3 kilometers (1.86 miles) of the nation's 413 hazardous waste facilities were people of color (Hispanics/Latinos, African Americans, Asians/Pacific Islanders, and Native Americans) (Bullard et al, 2007). Neighborhoods with hazardous waste facilities were 56% people of color compared to non-hosting neighborhoods, which were 30% people of color (Bullard et al., 2007). In areas with more than one hazardous waste facility (clustered facilities), people of color made up over two-thirds (69%) (Bullard et al., 2007). According to Robert Bullard, a primary author for the report, "People of color in 2007 were more concentrated in areas with commercial hazardous sites than in 1987" (2012, p. 24).

Path of Least Resistance

Another significant element of the EJ movement and EJ literature focuses on identifying and explaining the concentration of waste and pollution sources in minority and low-income communities. Many researchers have emphasized that industries follow the path of least resistance. Poor communities and communities of color are often seen as the path of least resistance for waste sites and other industries because the land is cheaper, and the residents have fewer resources and political influence to oppose siting (Bullard, 1994, 2005, 2012; Mitchell, 1993; Mohai & Bryant, 1992, Pellow, 2002). On the contrary, Bullard (1993, 2005) notes that waste facilities are rarely built in affluent white communities due to the use of the "not in my backyard" (NIMBY) principle. Bullard points out that "white homeowners have repeatedly mobilized against and defeated proposed sitings of so-called "locally unwanted land uses" (LULUs) – such as garbage dumps, landfills, incinerators, sewer treatment plants, garbage transfer stations, and recycling centers – in their neighborhoods" (Bullard, 1993, p. 323). Opposing waste sites is difficult for any community when it lacks the resources, political power, and mobilization. Moreover, the burdens of waste sites in communities of color "are exacerbated by other institutional barriers, such as housing discrimination and de facto residential segregation" (Bullard, 1993, p. 322). Researchers assert that government policies and the discriminatory practices and policies in zoning, land-use, housing, and bank loans have affected countless low-income communities and communities of color to endure a disproportionate amount of the country's waste and pollution (Bullard, 1993, 2005; Checker, 2005; Mohai & Bryant, 1992). Mortgage loan policies and low property values in communities with waste and polluting industries also hinder low-income residents from moving or buying their way out of their polluted environments (Bullard, 1993, 2005; Mohai & Bryant, 1992). The combination of these factors has led to the existing inequities in the distribution of the nation's waste and polluting industries. Through her fieldwork in Augusta, Georgia, Melissa Checker (2005) found that there are in fact "deep and troublesome connections between race and environmental pollution" (p. 304).

Throughout the last several decades, many EJ advocates have argued that the disproportionate siting of waste and other hazardous and polluting industries in low-income and minority areas is the outcome of racial and class discrimination (Taylor, 2014). Numerous studies have analyzed waste facility siting in poor and minority communities and have found empirical evidence that supports the disproportionate siting and racial and class discrimination theory (Bullard, 1983, 1994; GAO, 1983; UCC, 1987; Mohai & Bryant, 1992; Mohai & Saha, 2006, 2015). The disproportionate siting and discrimination theory is among the most controversial theories in EJ research, with many academics and policy-makers divided on both sides of the debate, particularly regarding the claim of racial discrimination or racism (Taylor, 2014). Such controversial debate has led to EJ studies that focus on the nature of communities at the time of siting. The positive correlation between waste facilities and race, and wealth incites two possible explanations often discussed in EJ literature. One explanation is that minorities lived (and were established) in communities before the waste facilities were built. The alternate explanation is that minority and low-income populations moved into the communities after the facilities were built. These explanations are referred to as the 'minority move-in hypothesis,' 'which-came-first' question (Pastor et al., 2001) or 'chicken-or-egg debate' (Pulido, 1996) in EJ literature.

Nature of Communities at Time of Siting and Changes Over Time

A significant strand of EJ literature focuses on the siting of waste facilities and examines the demographics and socioeconomics of communities at the time of siting. Examples of such work include Been (1994), Lambert & Boerner (1997), Liu (1997), Morellow-Frosch et al. (2002), Pastor, Sadd, & Hipp (2001), and Saha & Mohai (2006, 2015). Some of these studies analyzed national data, while others concentrated on particular states, regions or cities. Mohai and Saha (2015) conducted a national-level longitudinal study on waste facilities and used distance-based methods to examine demographics of neighborhoods before and after waste facilities were sited. Their study examined 319 hazardous waste facilities sited in the U.S. between 1966 and 1995. A consistent pattern was found of hazardous waste facilities being built in previously established neighborhoods consisting of people of low-income and people of color. Their research found demographic changes also occurred post-siting, particularly due to hazardous waste sites often being built in transition areas, where white populations have been moving out, and people of color have been moving in for at least a decade before the waste facility siting (Mohai & Saha, 2015).

In addition, EJ research has investigated the dispute that the frequency of waste sites and other locally unwanted land uses (LULUs) in low-income and/or minority communities is an outcome of market-driven changes that happen in areas after a waste site or other LULU is placed there (Been, 1994). In her study of this matter, Professor Vicki Been, among others, has discussed that waste sites and other LULUs may have situated in certain areas for various motives and may have been sited before minorities or low-income populations moved into the areas (1994). Subsequently, the siting of LULUs drastically reduced property and land values, which drew low-income and minority populations to move nearby and therefore altered the demographics of the area (Been, 1994; Liu, 1997). Been (1994) highlighted several factors or "market dynamics" that could cause such demographic changes: "poverty, housing discrimination, and the location of jobs, transportation, and other public services may have led the poor and racial minorities to 'come to the nuisance' – to move to neighborhoods that host LULUs – because those neighborhoods offered the cheapest available housing" (p. 1385).

Been (1994) reexamined the areas hosting waste sites that were formerly studied by the U.S. GAO (1983) and Bullard (1983). In regards to the GAO analysis, Been (1994) found that based on demographic data from 1970, "all of the host communities were disproportionately populated by African-Americans at the time of the sitings" (p. 1398). Been's findings indicate that market-driven dynamics did not essentially influence the results. Been (1994) used longitudinal analyses to reexamine Bullard's 1983 study to evaluate pre-siting and post-siting changes in Houston neighborhoods hosting municipal landfills and incinerators. Been (1994) found that "three of the seven landfills and two of the three mini-incinerators (or half of all the facilities) were sited in areas that were disproportionately African-American at the time of the siting" (p. 1403). In addition, between 1970 and 1990, the percentage of African Americans and low-income persons in areas with landfills had significantly increased. By 1990, nine of the ten neighborhoods were predominantly minority and seven of the ten neighborhoods were low-income or impoverished (Been, 1994).

Environmental justice studies have also analyzed historical connections between waste sites and neighborhoods in other urban areas. Lambert and Boerner (1997) studied changes between 1970 and 1990 in St. Louis, Missouri for census tracts with waste sites. They found mixed evidence on whether waste sites were sited in low-income and minority areas initially or whether minority and low-income populations moved into the areas after the waste facilities were built. However, in the 20-year span, the percentage of minority residents and percentage of impoverished residents increased vastly in areas with hazardous TSDFS, landfills, and incinerators (Lambert & Boerner, 1997). Pastor, Sadd, and Hipp (2001) used 1970-1990 census tract data and facility siting dates to examine siting patterns of TSDFs in the city of Los Angeles. Their findings were consistent with Mohai and Saha's (2015) regarding demographic changes in communities becoming predominantly minority attract the building of waste disposal and other hazardous facilities. In addition, they found that race is a stronger predictor than socioeconomic characteristics for which areas are targeted for hosting waste and other hazardous facilities (Pastor et al., 2001). According to Pastor et al. (2001), in the Los Angeles area, "…minorities attract TSDFs but TSDFs do not generally attract minorities" (p. 18).

Numerous EJ researchers and advocates assert that despite the progress of the EJ movement in the last several decades, race continues to be a major factor for the distribution of waste and polluting industries (Bullard, 2012; Mohai & Saha, 2006, 2015; Taylor, 2014). Environmental justice goes beyond waste facility siting; it also encompasses the disproportionate siting of other polluting industries. National reports consistently find that communities of color and low-income/poor communities are disproportionately affected by environmental pollution, hazards and burdens. In "Who's in Danger? Race, Poverty, and Chemical Disasters," a collaborative report by several environmental organizations, the demographic characteristics of the estimated 134 million people living in vulnerable areas of the 3,433 facilities that manufacture, use or store hazardous chemicals in the U.S. are discussed (Orum, Moore, Roberts, & Sanchez, 2014). The data presented in the report indicates that residents in vulnerability zones (average radius of 4 miles) are disproportionately Latino or African American and have lower incomes and property values than the national average (Orum et al., 2014). Of the millions living nearby chemical facilities, 3.8 million people live within fenceline zones, which are the closest proximity to the chemical facilities (Orum et al., 2014). Key findings indicate that in fenceline zones, compared to the national averages: the poverty rate is 50% higher, home values are 33% lower, the percentage of African Americans is 75% higher, and the percentage of Latinos is 60% higher (Orum et al., 2014).

Likewise, the Gulf Coast region of the United States has been a prime location for the petrochemical industry over the decades. In "Living and Dying in Louisiana's 'Cancer Alley,'" Beverly Wright describes how the "unholy alliance between government and industry" has caused detrimental consequences for the people of Louisiana (2005, p. 89). Louisiana's low-priced land, easy access to the Mississippi River, and the increasing local oil production has appealed to many petroleum and chemical companies (Wright & Bullard, 2005). In the estimated 85 miles between Baton Rouge and New Orleans, widely known as "Cancer Alley" and the "Petrochemical Corridor," there are over 130 petrochemical facilities, which are responsible for producing 25% of the nation's petrochemicals (Wright & Bullard, 2005). This industrial corridor reports some of the highest concentrations of toxic emissions to the air, land, and water in the entire U.S. (Wright & Bullard, 2005).

GIS in Environmental Justice Research

Many EJ studies have implemented the use of GIS to analyze the correlation between sociodemographic characteristics and environmental burdens such as waste facilities and other LULUs (Anderton et al., 1994; Glickman et al., 1995; Mohai & Saha, 2006; Sheppard et al., 1999; U.S. GAO, 1995). GIS is an integrated technology framework used to capture, store, manage, analyze, and visually present spatial and demographic data (Esri, 2019). Over the last couple of decades, GIS has become a multidisciplinary method. GIS methods are often implemented by environmental scientists and social scientists such as urban planners, anthropologists, sociologists, health researchers, and geographers to study matters such as water resources, pollution, climate change, urban planning, land use, health and social equity, and environmental justice. The use of GIS has been instrumental for supporting environmental justice and influencing decisions and policymaking (Maantay, Chakraborty, & Brender, 2010). GIS technology facilitates the visual presentation of the geographic distribution of waste sites and populations, as well as measurable data for economic, racial, and ethnic make-up of populations near waste sites and other LULUs.

Since the 1990s, GIS has been a widely used tool for researchers to examine the spatial and demographic aspects of environmental justice issues (Anderton et al., 1994; Bowen et al., 1995; Chakraborty and Armstrong, 1997; Chakraborty et al., 1999; Maantay, 2002; Morello-Frosch et al., 2001; Sheppard et al., 1999). EJ researchers and advocates have used GIS tools primarily to examine potential environmental injustice areas by analyzing and mapping community sociodemographic characteristics and proximity to LULUs (Maantay, 2002; Maantay et al., 2010). Over the last couple of decades, “it has become increasingly prevalent to try to map instances of environmental injustice, usually by geographically plotting facilities or land uses suspected of posing an environmental and human health hazard or risk, and then trying to determine the racial, ethnic, and economic characteristics of the potentially affected populations" (Maantay, 2002, p. 161). This has often resulted in vivid maps displaying waste sites, toxic facilities, and other LULUs concentrated in areas with predominantly minority residents (UCC, 1987; Maantay, 2002; Maantay et al., 2010).

GIS has become a preferred method to incorporate into EJ research in part due to the visual intrigue of the resulting maps. The maps generated with GIS applications and tools assists researchers and the public to more easily see, explore, and understand patterns and connections. Moreover, GIS and its generated maps have become increasingly beneficial to EJ researchers and advocates in helping identify environmental burdens, pollution, and other problems that place populations at risk. A population's proximity to waste sites and other LULUs is a prevalent way that GIS is used for evaluating the risk linked with such burdens. The boundaries for evaluating the risk a waste site or other LULUs creates and the boundaries for defining the populations potentially affected are disputed among EJ researchers (Anderton et. al, 1994; Been, 1994; Chakraborty et al. 2011; Sheppard et al. 1999). This clash is due to the data and methods used for estimating risk and locations of affected populations. Different spatial boundaries and methods can be used to measure the extent of risk and characteristics of populations affected by waste sites and other LULUs. However, generally, EJ studies do not distinctly define the spatial dispersion of environmental risk or burdens. As some EJ researchers have noted, environmental burdens and risk are "often determined simplistically and defined as whether the population is in the same ZIP code, census tract, county, or municipal boundary as the noxious facility" (Maantay, 2002, p. 164). However, there can be significant differences in assessing the extent and characteristics of the populations affected by waste sites and other LULUs depending on the method of spatial analysis and the selected unit of analysis (Chakraborty et al. 2011; Maantay, 2002).

The Unit of Analysis for Environmental Justice Research

The unit of analysis for environmental justice research has been a matter of ongoing debate in determining the appropriate unit of analysis (Anderton et al., 1994; Been, 1995; Glickman et al., 1995). Units of analysis such as national, regional, state, county, zip code, census tract, or census block group are often used for EJ research. The spatial definition of community or neighborhood and the selection of the unit of analysis has been left to researchers to decide, and as a result, studies have differing results (Anderton et al., 1994; Glickman et al., 1995; Maantay, 2002). In the beginnings of EJ research, five-digit zip codes were the main unit of analysis. The national study conducted by UCC (1987) was the first to use zip codes as the unit of analysis to determine that race was the most significant variable in the location of hazardous waste facilities (TSDFs). Some studies have disputed the conclusions of the UCC (1987) study as inaccurate due to the selection of data and methodology (Anderton et al., 1994; Been, 1994). According to Anderton et al. (1994), zip codes are too big to use as the unit of analysis because they do not portray the spatial correlation between proximity to hazardous waste facilities and sociodemographic factors. However, Sui (1999) and others note that a best or most appropriate unit of analysis for EJ research does not exist.

Over the last couple of decades, various methods of statistical and spatial analysis have been used in EJ research to determine if there is a correlation between race, economic status, and waste facilities. In many statistically based EJ studies, evidence of environmental injustice is found when communities that host waste facilities or other LULUs have considerably higher proportions of minority and/or poor residents than non-host communities. An important aspect in EJ research is determining the characteristics of populations that host waste sites and other LULUs. This inquiry can be completed using GIS and involves economic, demographic and boundary data, waste facility data, as well as the spatial analytic functions available in GIS software and applications.

Data and Methods

The goal of this study is to conduct a metropolitan area analysis of the location of MSWLs in relation to community race/ethnicity and income. GIS software was used to visually represent and analyze the location of Greater Houston's MSWLs and the racial/ethnic and income characteristics of nearby communities. The following question was explored: What are the predominant racial/ethnic and income characteristics of communities that contain MSWLs?

Study Area

The Houston MSA (Greater Houston) was the chosen study area based on several factors. First, this MSA is located in southeastern Texas along the Gulf of Mexico. Due to its prime location, Houston is one of the primary ports in the nation. Houston is regarded as the "Petro Metro" and the "energy capital of the world" (Greater Houston Partnership, 2019), with many petrochemical, manufacturing, and industrial facilities located throughout the metropolitan area. In addition to such facilities, waste sites present an additional nuisance and risk to the environment and nearby communities. The variety of polluting industries in the Houston MSA has deemed it an area for EJ concern and examination. Second, the Houston MSA has a racially/ethnically diverse population, which makes it an appropriate study area for this research. Lastly, prior EJ studies have examined the Houston area (Bullard, 1983; Been, 1994; GAO, 1995), and this research aims to add to EJ research in Houston by analyzing current data for the metropolitan area's MSWLs and the racial/ethnic and income characteristics of communities that contain MSWLs.

The Houston MSA is one of the largest metropolitan areas in the U.S., with an estimated population of 6.8 million (U.S. Census Bureau, 2017). The three most populated cities in the MSA include Houston, Sugar Land, and The Woodlands. The Houston MSA consists of Harris county and eight other counties in southeastern Texas (as shown in Figure 1), and encompasses 9,444 square miles (U.S. Census Bureau, 2019). According to 2017 American Community Survey (ACS) estimates, non-Hispanic Whites account for 36.1 % of the MSA population, with Hispanics/Latinos (37.3%), non-Hispanic Blacks/African Americans (16.9%), and Asians (7.8%) representing the largest minority groups.

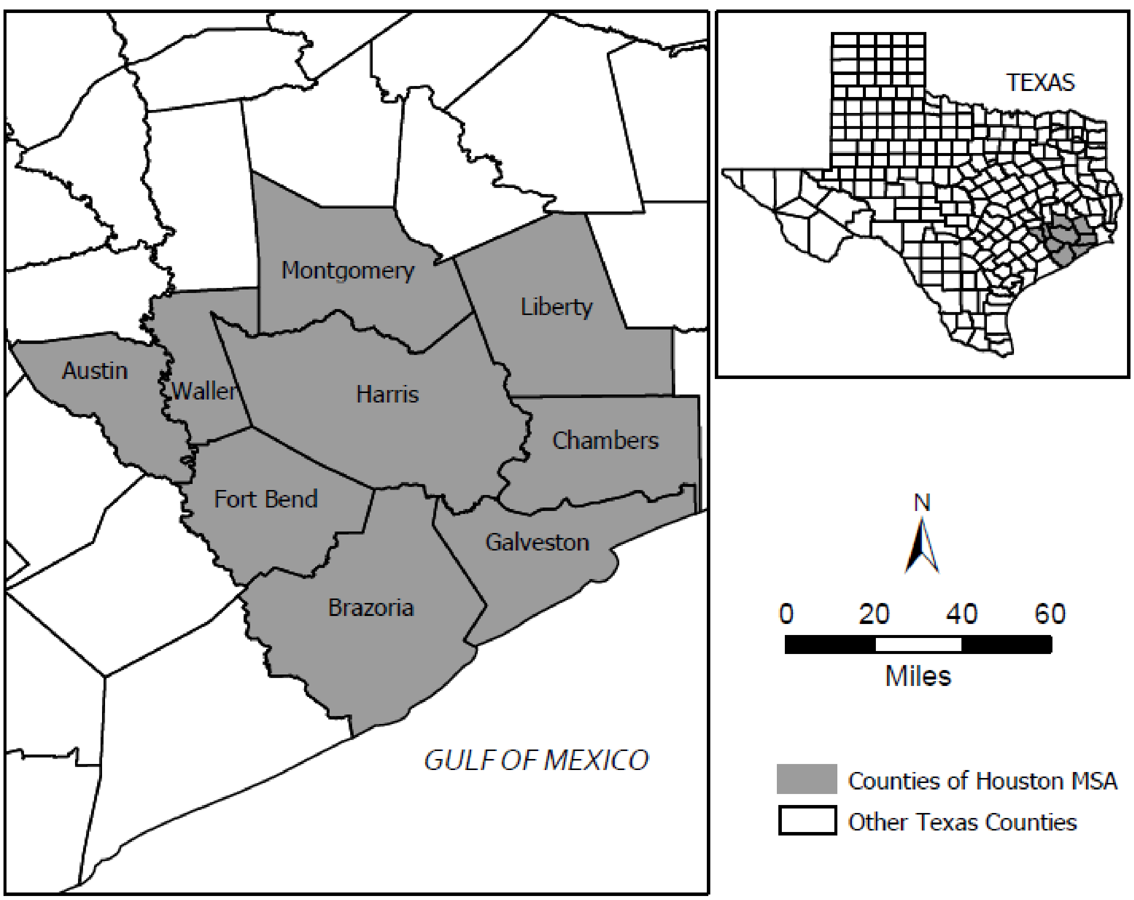

Figure 1. Location of the Houston Metropolitan Statistical Area, Texas, USA, 2019.

Data Collection

Data was collected from the U.S. Census Bureau online databases and Texas Commission on Environmental Quality (TCEQ) online databases. Data from the U.S. Census Bureau was used due to its comprehensive and notable collection of demographic and economic data from the U.S. population. In addition to gathering data about the national population every 10 years, the Census Bureau gathers data every one to five years through other household surveys such as the American Community Survey.

The Waste Permits Division of the Texas Commission on Environmental Quality (TCEQ) is responsible for issuing permits to several types of waste facilities in the state of Texas. An electronic data file with permitted waste facilities was acquired from TCEQ online databases. The TCEQ's electronic file of permitted facilities included various information regarding waste facilities in Texas such as geographic coordinates of each facility (latitude and longitude), unique facility identifier, permit number, facility type, status of facility (active, inactive, etc.), facility address, etc. Additional information for the MSWLs was not needed for the purposes of this research. Data utilized from the TCEQ electronic file included the geographic coordinates, addresses, and facility names of permitted, active MSWLs for municipal and construction and demolition (C&D) waste located in the Houston MSA. These types of landfills were included in this research because they are the most common and heavily used MSWLs in the Houston MSA (TCEQ, 2017).

Census tracts were used as the unit of analysis, to define communities, and to obtain racial/ethnic and income data. A census tract is an area established by the Census Bureau, with an area comparable to a neighborhood/community. A census tract generally encompasses a population of 1,200 to 8,000, with an average of 4,000 inhabitants (U.S. Census, 2019). Census tracts were chosen as the unit of analysis because they represent the smallest geographic unit for reliable 5-year estimates of U.S. demographic and household data (ACS, 2017). Electronic data files (tables) containing racial/ethnic and income statistics for census tracts in the Houston MSA were collected from the U.S. Census Bureau online databases. The files containing the racial/ethnic and income statistics were collected through the ACS (2013-2017), and were chosen for use in this research because their 5-year estimates are the most current. This research aimed to select explanatory variables that are often used in EJ studies (Bullard, 1983; Been, 1995; Chakraborty et al., 2011; GAO, 1995). To measure racial/ethnic characteristics of census tracts, this study included the racial and ethnic groups with the highest proportions in the Houston MSA as outlined by ACS 2013-2017 estimates: non-Hispanic White, Hispanic/Latino, Black/African American, and Asian. Each census tract was identified by a predominant racial/ethnic category, which was based on the racial/ethnic group with the highest proportion in the census tract. The strength of predominance ranged from 0-15%, 15-75%, and 75-100%.

Median household income was used to measure income characteristics of census tracts. Three categories were used to measure the median household income of census tracts: lower-income, middle-income, and upper-income. According to the 2013-2017 ACS 5-year estimates (2017), the median household income for the U.S. was $57,652. The Pew Research Center (2018) defines middle-income households as those with an income between two-thirds and double the U.S. median household income. Based on this definition, the middle-income category for this research consisted of households with incomes that ranged from $38,435 to $115,304. Households with incomes less than $38,435 made up the lower-income category, while households with incomes greater than $115,304 made up the upper-income category.

Two other major data sets collected from the Census Bureau were 2017 cartographic boundary files of Texas counties and census tracts. These files were obtained from the census topologically integrated geographic encoding and referencing (TIGER) database. The TIGER/Line files and shapefiles database do not contain demographic data; however, they contain geographic identifications that can be associated to demographic data from the U.S. Census Bureau.

GIS Analysis

All of the collected data was imported, stored, and managed with ArcGIS software and features by Esri (Redlands, CA). A geodatabase was created for this project and included the 2017 U.S. Census TIGER/Line shapefiles (county and census tract cartographic boundaries), ACS 2013-2017 data, and MSWLs data from the TCEQ. Through use of ArcGIS software and geoprocessing tools, the cartographic boundaries and statistical and geographic data for the Houston MSA were spatially joined and visually presented at the county and census tract level. ArcGIS software was used as the analytic method for this research due to its suitability for EJ research. With ArcGIS software, it was possible to integrate cartographic boundaries, racial/ethnic and median household income statistics, and geographic locations of MSWLs to assess EJ and visually present the joint data in the form of maps.

ArcGIS software tools include various methods of data analysis. This research applied spatial and proximity analysis, using spatial coincidence (unit-hazard coincidence) and distance-based analyses. The unit-hazard coincidence (Mohai & Saha, 2006) method has been commonly used to identify the locations of environmental hazards within each unit of analysis (e.g. county, zip code, census tract). Spatial units that contain a hazard are considered host units, and spatial units that do not contain a hazard are considered non-host units. This method supposes that inhabitants living in the host unit are closer to the environmental hazard than inhabitants that do not live in the host unit (Maantay et al., 2010). Several well-known EJ studies have used the unit-hazard coincidence method to determine disparate risk and burdens (Anderton et al., 1994; Been, 1995; UCC, 1987). For this research, unit-hazard coincidence analysis was applied by locating each mapped MSWL and identifying the host census tract. Any census tract that contained a MSWL was documented and used for comparison of the racial/ethnic and median household income characteristics. Some of the MSWLs were located near the boundary of more than one census tract; therefore, all inhabitants of a host unit were not equally nearby or exposed to the landfill. Another limitation of the unit-hazard coincidence analysis was that the exact location of the MSWL was not considered, and therefore did not include inhabitants in a non-host unit in proximity to the MSWL.

To extend the unit-hazard coincidence analysis, a distance-based analysis was applied. Numerous EJ studies have used buffer analysis (Mohai & Saha, 2006; Sheppard et al., 1999; UCC, 2007; U.S. GAO, 1995;). The buffer analysis method is widely used to create circular buffers of numerous distances around environmental hazards to identify areas and populations exposed to its potential effects (Maantay et al., 2010; Mohai & Saha, 2006). For this research, the buffer analysis was applied by creating a circular buffer of 0.5-mile radius around each MSWL. Any census tract within the 0.5-mile buffer area of a MSWL was documented and used for comparison of the racial/ethnic and median household income characteristics.

Results

The spatial distribution of MSWLs in the Houston MSA is depicted as a map in Figure 2. For this map, the census tracts were grouped by county within the study area. There are twenty-eight active MSWLs in the Houston MSA. Of these twenty-eight MSWLs, thirteen are for municipal waste and fifteen are for construction and demolition debris (TCEQ, 2019). The MSWLs are distributed throughout the Houston MSA, located in six of nine counties: Brazoria, Chambers, Fort Bend, Galveston, Harris, and Montgomery (no MSWLs are located in Austin County, Liberty County, and Waller County). Harris County has fourteen MSWLs, or 50% of all MSWLs in the Houston MSA.

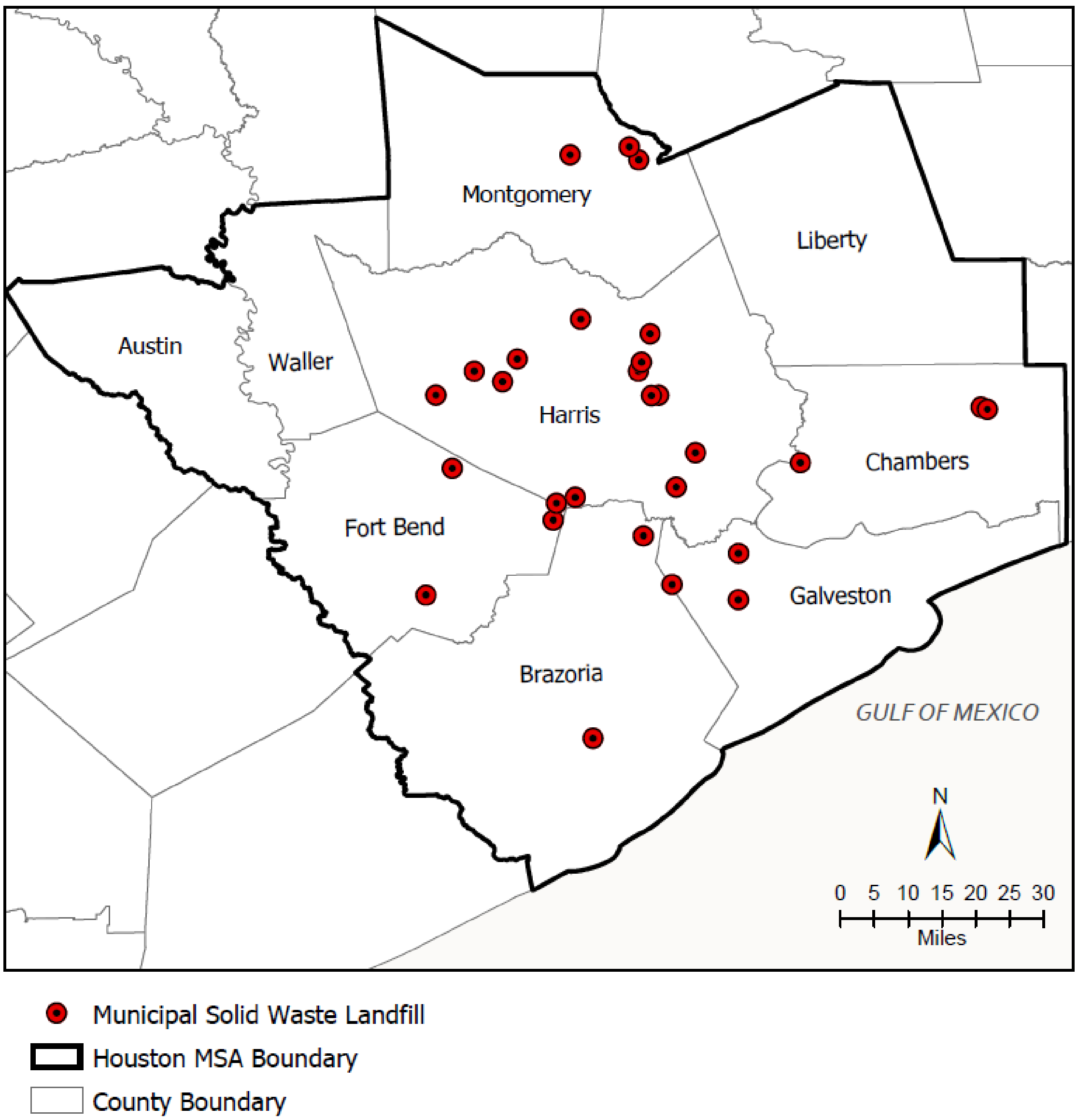

Figure 2. Location of MSWLs in the Houston Metropolitan Statistical Area, 2019.

There are 1,072 census tracts in the Houston MSA. Each MSWL was located within the boundaries of one census tract. For the unit-hazard coincidence analysis, there were twenty-seven host census tracts, or 2.5% of all census tracts in the Houston MSA contained at least one MSWL. One of the twenty-seven host census tracts contained two MSWLs within its boundary – the Gulf West Landfill and Chambers County Landfill were both located within the boundaries of one census tract in Chambers County. In addition to the twenty-seven host census tracts, twenty-eight non-host census tracts (2.6% of Houston MSA census tracts) were within the 0.5-mile buffer area of at least one MSWL. Therefore, for the buffer analysis, fifty-five census tracts (5.1% of all Houston MSA census tracts) were within a 0.5-mile radius of at least one MSWL.

The spatial distribution of race/ethnicity and MSWLs is shown in Figure 3. The twenty-eight MSWLs in the Houston MSA were located within twenty-seven host census tracts (one host census tracts contained two MSWLs within its boundaries). Among the twenty-seven host census tracts, thirteen (48.1%) had a predominantly Hispanic/Latino population, ten (37%) had a predominantly non-Hispanic White population, three (11.1%) had a predominantly Black/African American population, and one (3.7%) had a predominantly Asian population. The spatial distribution of income and MSWLs is shown in Figure 4. The median household income for the twenty-seven host census tracts ranged from $32,009 to $105,677. Based on the household income categories (lower-income, middle-income, and upper-income), four of the host census tracts (14.8%) were lower-income and twenty-three of the host census tracts (85.2%) were middle-income. There were no host census tracts in the upper-income category.

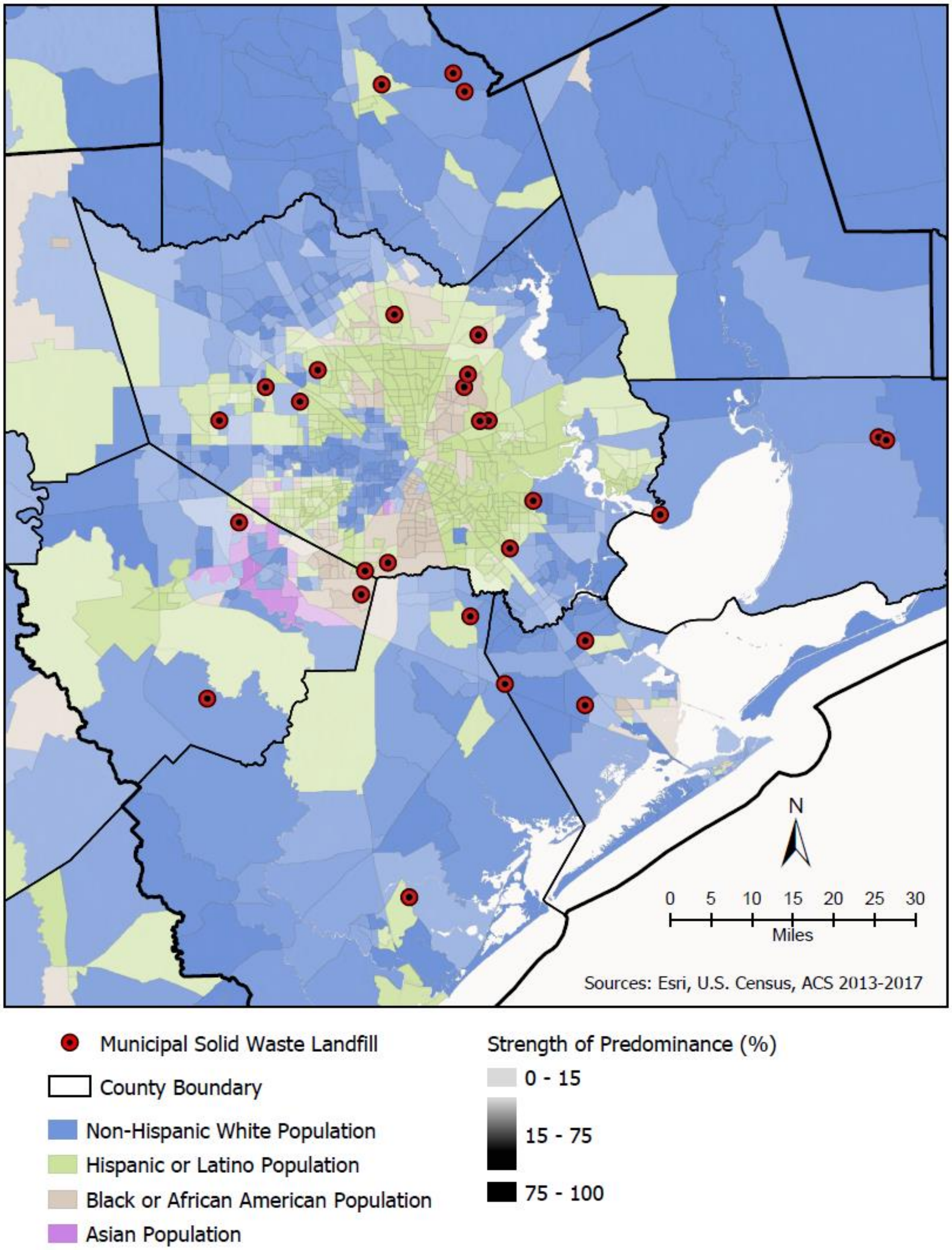

Figure 3. Predominance of Race/Ethnicity by Census Tract and MSWLs in the Houston MSA, 2019.

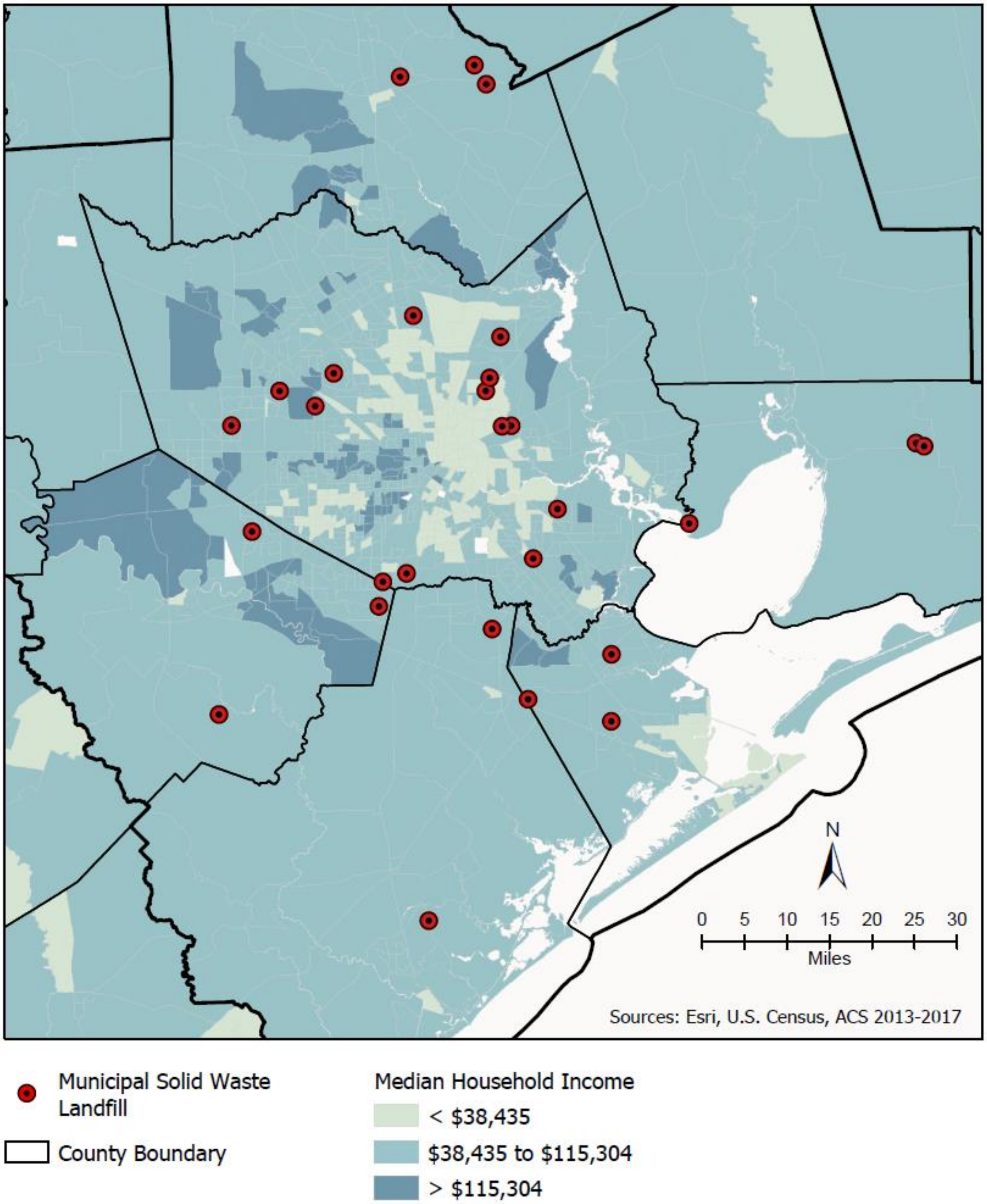

Figure 4. Median Household Income by Census Tract and MSWLs in the Houston MSA, 2019.

In addition to the twenty-seven host census tracts, twenty-eight non-host census tracts were within a 0.5-mile radius of at least one MSWL. In total, fifty-five census tracts were within a 0.5-mile radius of at least one MSWL. Among these fifty-five census tracts, twenty-seven census tracts (49.1%) had a predominantly Hispanic/Latino population, twenty census tracts (36.4%) had a predominantly non-Hispanic White population, seven census tracts (12.7%) had a predominantly Black/African American population, and one census tract (1.8%) had a predominantly Asian population. The median household income for the fifty-five census tracts ranged from $29,286 to $140,000. Seven of the census tracts (12.7%) were lower-income, fourty-seven census tracts (85.4%) were middle-income, and one census tract (1.8%) was upper-income.

Discussion

This study examined the location of Houston MSA's MSWLs and the racial/ethnic and income characteristics of communities that contain MSWLs. The results suggest that MSWLs in the Houston MSA are located in Hispanic/Latino communities, Black/African American communities, and non-Hispanic White communities. Moreover, nearly half of all communities within a 0.5-mile radius of a MSWL consist of predominantly Hispanic/Latino residents. The results also indicate that MSWLs are located in lower-income and middle-income communities.

Previous studies found that waste sites in Houston were disproportionately located in Black/African American communities (Been, 1994; Bullard, 1983). While this study area encompassed the Houston MSA, a larger study area than previous studies, the results suggest that the area's demographics have changed over time and many communities near MSWLs are now predominantly Hispanic/Latino as well as non-Hispanic White. These results may be linked to the high proportion of these two racial/ethnic groups in the Houston MSA. Based on 2017 ACS estimates, these two racial/ethnic groups make up more than 70% of the population in the Houston MSA, with non-Hispanic Whites accounting for 36.1 % and Hispanics/Latinos accounting for 37.3%.

However, some of the results presented here are consistent with some EJ studies. Approximately half of all communities near MSWLs in the Houston MSA consist of predominantly Hispanics/Latinos, seven are predominantly Black/African American communities, and one is a predominantly Asian community. In sum, these minority communities account for a majority of communities near Greater Houston's MSWLs. This data can be related with previous research by Mohai & Bryant (1992), and Pastor, Sadd, & Hipp (2001) who found that most waste sites are located in minority communities. The results presented here demonstrate that in terms of income, the location of Greater Houston's MSWLs is negatively correlated with upper-income communities. This finding is consistent with prior studies that have documented that waste facilities are rarely found in affluent communities due to the use of the "not in my backyard" (NIMBY) principle (Bullard 1993, 2005). In addition, upper-income communities often have more resources and political influence to oppose waste sites or other LULUs (Bullard, 1993, 2005; Mitchell, 1993; Pellow, 2002).

It is important to consider the limitations of this study. This study examined the location of active MSWLs in the Houston MSA as of September 2019. The results presented here reveal the most current (ACS 2013-2017) race/ethnicity and income data for the Houston MSA population. Therefore, the evaluation of the current location and distribution of MSWLs could not address the race/ethnicity and income characteristics of nearby communities at the time the MSWLs were sited. In addition, this study used latitude and longitude coordinates to locate each MSWL and thereby establish the census tracts that contain MSWLs. Upon viewing the maps/figures, the points used to symbolize MSWLs could lead to misclassification of the census tracts that contain MSWLs.

However, while using GIS analysis tools and software, points were displayed at a close-range scale to document and report accurate location of MSWLs, census tracts, and race/ethnicity and income characteristics.

This study focused on examining the race/ethnicity and income characteristics of communities in the Houston MSA that contain MSWLs, however, many similar communities experience the burdens and risks of waste sites across the state and the nation. Landfills, particularly MSWLs, are regarded as a necessary disposal method to manage the millions of tons of waste generated in the U.S. Waste is a natural, necessary element of life and an unavoidable outcome of human activities. Each of us contributes to the waste that makes it way to MSWLs, however, only some communities live near these environmental burdens and sources of pollution. There is significant importance in studying the populations that live near MSWLs for environmental justice concerns as well as public health concerns. While U.S. EPA and TCEQ regulations are aimed at limiting pollution, environmental pollution caused by MSWLs cannot be completely eradicated. MSWLs present numerous public health concerns for nearby communities including potential for air, land, and water contamination, diesel emissions from garbage trucks and landfill machinery used daily, as well as constant malodors from waste. Limited research has been conducted on the health impacts of waste sites, however, a few studies have found that exposure to air emissions from MSWLs can have health effects on nearby populations. The results of these studies suggest that there is an increased risk of preterm births and low birth weight for infants born to women living near MSWLs (Elliot et al., 2001; Goldberg, Goulet, Riberdy, & Bonvalot, 1995). In addition, living near MSWLs is linked with higher risks of respiratory conditions (Hertzman, Hayes, Singer, & Highland, 1987). Environmental justice advocates voice concerns for waste sites and their potential impacts on nearby populations; however, the scarcity of research examining their correlation to health effects is problematic (Maantay et al., 2010). Although health was not emphasized in this research, future research could expand this study by evaluating aspects of public health for populations near Greater Houston's MSWLs. Future research could examine the effects MSWLs have on nearby residents' health and quality of life. For example, do MSWLs and other waste sites detract health-promoting amenities (e.g. health clinics, food stores, fitness centers, parks) in nearby communities? The main principle of EJ is that all people – regardless of race, color, ethnicity, national origin, or income – have the right to a safe and healthy environment. In order for environmental justice to prevail, there is a need to minimize environmental pollution, burdens, and hazards for all communities, especially for those that contain waste sites or other LULUs. In order to achieve this, there is a need for improved environmental policies and regulations, zero waste initiatives, as well as continuous collaboration among environmental researchers, social scientists, local, state and federal governments, industries, environmental organizations and advocates, and communities to help create a safe and healthy environment for everyone.

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