STAYING AFLOAT:

ANALYZING WATER SHUTOFFS

THROUGH THE LENS OF RACE

by

Meerea Kang

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This Thesis for the Master of Environmental Studies Degree

by

Meerea Kang

has been approved for

The Evergreen State College

by

Tyrus Smith, Ph. D. Member of the Faculty	Date
Steve Hamai Seattle Public Utilities	Date

ABSTRACT

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Analyzing Water Shutoffs Through the Lens of Race

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Reliable access to safe, affordable drinking water is unevenly distributed across the United States. Water unaffordability has escalated to a crisis level for many low-income populations and increasing evidence suggests that rising water rates disproportionately burden communities of color. Due to legacies and current practices of institutional and structural racism in the U.S., the research question inquires whether there are racial disparities with water shutoffs in Seattle, Washington. By analyzing over a decade of Seattle Public Utilities' water shutoff data with the U.S. Census Bureau's American Community Survey demographic estimates, regression results and GIS mapping indicated that water shutoffs occurred with statistically significant frequency in neighborhoods historically resided by people of color. This research recommends utilities address underlying issues with affordability by reformatting data processes and overhauling regressive rate structures to provide equitable water services to the communities they serve.

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감사하고 사랑합니다.

Introduction

Utilities regularly shut off water services when residents fail to pay their utility bills, effectively severing them from vital daily activities to maintain a healthy living standard. This study offers a fresh perspective on the issue of water disconnections by factoring in the racial demographics of ratepayers. Embedded in the fabric of American society, structural racism segregated people of color across the country, formulating chronic economic disparities and uneven access to opportunity for generations. As such, I investigated which customers most likely experienced water shutoffs in Seattle, Washington beyond the bounds of formerly researched economic measures. By looking into who can afford to pay their utility bill through the lens of race, this study inquired: are there racial disparities with water shutoffs in Seattle?

This research analyzed single-family residential water shutoffs by Seattle Public Utilities from 2008 through 2019 using regression and GIS mapping. The background section lays the contextual groundwork of the study area by speaking to issues with affordability in Seattle, structural and institutional racism, and an overview of Seattle Public Utilities. The literature review covers water security and affordability in the United States. In the methods section, I describe the water shutoff data before delving into the outline for statistical analyses and GIS mapping. The results reveal the study findings and segue into the discussion section, where I confer the implications of the research as well as recommendations before reaching a conclusion.

Background

Housing in Seattle

Seattle has encountered staggering growth and rapid development of core neighborhoods within the past decade. Largely due to a booming tech industry, the population surged by 22.4% between 2010 and 2018, ranking Seattle as the fastest-growing major city within the United States (DeMay, 2015; U.S. Census Bureau, n.d.-a; Balk, 2018-a). However, a surging population has placed stress on a mounting housing crisis. Rents have skyrocketed by 69% in the Greater Seattle region since 2010, over twice the national average of 32% (Rosenberg, 2018). Homelessness has risen in the region as well and though this crisis is a multi-faceted issue, researchers found that a 5% increase in rent would result in 258 more people becoming unhoused (Glynn et al., 2017). Factors grossly inflating the housing market include a shortage of affordable housing, high demand for limited housing stock, zoning restrictions, and real estate investments by hedge funds and private equity firms (Herbold, 2016; Talton, 2018). From 2012 to 2018, the median sale price for homes more than doubled to $769,000 for a single-family home (Zillow, 2020). Houses once affordable for middle-class families mere decades ago have sold for nearly a million dollars in 2016 (Rosenberg, 2016).

Along with unaffordable housing, swelling population density and economic vitality have subsequently given rise to increasing income inequality and gentrification, which has shifted Seattle’s makeup. Between 2000 and 2010, Mitchell et al., 2018 assessed that 50% of the census tracts within Seattle have gentrified, ranking it the third most gentrified American city. In King County, the median household income increased by over 78% from $53,157 in 2000 to $95,009 in 2018 (King County, 2018), yet this figure masks a widening wage gap. Retail salespersons and software developers consist of the two most common occupations in the Greater Seattle area, but the average annual income for a software developer ($133,590) was 3.6 times greater than for a retail salesperson ($37,230) (U.S. Bureau of Labor Statistics, 2018a; 2018b). The American Community Survey's estimates for median household income by race in Table 1 (U.S. Census Bureau, n.d.-b) also highlight disparities in this majority-white city, as white households earned three times the median income of American Indian and Alaska Native households, and 2.5 times more than black households (U.S. Census Bureau, n.d.-b).

Table 1

Seattle Median Income by Race in 2018

Race/Ethnicity	Median Income (U.S. Dollars)
Asian	77,487
American Indian & Alaska Native	31,327
Black or African American	38,366
Hispanic or Latinx	65,903
Multiracial	68,612
Native Hawaiian & Pacific Islander	72,117
Other	53,724
White	95,941

Note. Adapted from "Median Income in the Past 12 Months (in 2018 Inflation-Adjusted Dollars)," by U.S. Census Bureau.
https://data.census.gov/cedsci/table?q=Seattle&g=1600000US5363000&tid=ACSST5Y2018.S1903&hidePreview=false&vintage=2018&cid=S1901_C01_001E&layer=place&t=Income%20and%20Earnings

Homes in neighborhoods historically resided by communities of color face the greatest risk of displacement from gentrification in Seattle (OPCD, 2016), such as the culturally rich epicenters of the Chinatown-International District and the historically black Central District. An analysis by the City of Seattle assessed that the Chinatown-International District has one of the highest risks of displacement within the city, as new developments continue to increase within and around the neighborhood (OPCD, 2016; Robinson, 2018). In 1970, nearly half the residents in the Central District were black; by 2010, the population dropped to approximately 20% and has since then decreased further (Morrill, 2013; Balk, 2016).

Neighborhoods where people of color have been priced out of were originally born from racial segregation by banking and housing institutions. Homeownership and housing appreciation have been the foundational ways Americans accumulate wealth, with home equity accounting for 60% of the middle class' wealth (Shapiro, 2006). However, the opportunities and advantages stemming from property ownership have almost exclusively benefited white households as people of color have systematically been denied housing through segregation, displacement, and exclusion. In 1926, the U.S. Supreme Court legitimized racially restrictive covenants, which legally allowed property owners to prohibit the occupation, lease, or purchase of real estate based on race (Brooks et al., 2013). As an example, a racially restrictive covenant in northeast Seattle's Laurelhurst neighborhood read (Seattle Civil Rights & Labor History Project, n.d.):

> No person or persons of Asiatic, African or Negro blood, lineage, or extraction shall be permitted to occupy a portion of said property, or any building thereon; except domestic servants may actually and in good faith be employed by white occupants of such premises.

Numerous neighborhoods across Seattle normalized this practice until racially restrictive covenants lost legal enforcement in 1948.

The federally condoned practice of redlining isolated communities of color into neighborhoods that lending institutions wrote off as "hazardous," making loans in these areas prohibitively expensive or unavailable. Using race to determine credit risk made it difficult for people of color to purchase homes and sabotaged wealth-generating opportunities that families could have earned from capital investment. A 2018 study that analyzed redlining and its impacts on neighborhoods today revealed the persistent effects of discriminatory housing and market practices (Mitchell et al., 2018). Three out of four redlined neighborhoods continue to struggle economically, with 63% of these neighborhoods remaining majority people of color. In contrast, 91% of the neighborhoods deemed "best" comprise of middle-to-upper income residents, with 85% of these areas still predominantly white. The study findings suggested that cities with minimal variations over the decades in neighborhood racial composition have significantly greater economic inequality today.

Residents of historically redlined areas often undergo displacement when their neighborhood gentrifies. The greater influx of economic activity habitually results in landlords raising rents to counterbalance rising property taxes. In addition, homeowners commonly decide to sell their homes rather than pay escalating property taxes from increasing home values. Gentrification was associated with decreased segregation but increased economic inequality due to racial and financial differences between residents who have historically lived in these neighborhoods and newcomers (Mitchell et al., 2018). As the cost of living within city limits overwhelms financially constrained residents, trends reveal communities of color have migrated from metropolitan areas to neighboring suburbs (Frey, 2011). Displacement of black residents in Seattle has led to the subsequent growth of black communities in the nearby cities of Renton, Kent, and Auburn (OPCD, 2016; Adolph, 2017; Balk, 2018-b).

Congress passed the Housing Rights Act in 1968, which formally banned exclusionary practices based on race (Brooks et al., 2013), but legacies of these practices and racial bias still linger in the housing system. Forty-five percent of African Americans, 31% of Latinx, 25% of Asian Americans, and 17% of Native Americans state that they have personally experienced discrimination when trying to rent or buy housing, compared to 5% of whites (NPR et al., 2018). In a study that estimated the level of racial discrimination in mortgages securitized by Fannie Mae and Freddie Mac, researchers found that lenders charged African American and Latinx borrowers 7.9 more basis points for purchase mortgages and 3.6 more basis points for refinance mortgages, costing them $765 million in extra interest per year (Bartlett et al., 2019). Not only does racial bias undermine the ability of people of color to access housing, but it also misprizes property values. Due to racial bias, homes in black neighborhoods are undervalued by an average of $48,000 per home, culminating in losses of $156 billion for homeowners (Perry et al., 2018).

Nationally, the homeownership rate for whites remained the highest out of all racial categories at 73% in 2019, compared to 57% for Asians, 47.1% for Latinx, and 42.9% for African Americans (JCHS, 2019). The median wealth of white families was $141,900 compared to $11,000 for black families and $13,700 for Latinx families in 2013 (Kochhar et al., 2014). Racial disparities in wealth accumulation are so deeply entrenched that it would take the average black family 228 years to accumulate the same amount of wealth white families presently enjoy (Asante-Muhammed et al., 2016).

Disinvestment from discriminatory housing practices shaped the realities of where and how communities of color live today. Housing is more than shelter—the neighborhood one resides in provides access to wealth, education, health, safety, and other societal resources. Racial stratification in housing thereby culminates in disparate access to opportunity and financial outcomes for communities of color.

Regressive Taxes

Washington State has a regressive tax system, where lower-income households pay a disproportionate amount of taxes compared to higher-income households. In 2018, Washington had the most unfair state and local tax system in the country, since families that earned less than $24,000 annually (poorest 20%) paid 17.8% of their income towards taxes, compared to families that earned more than $545,900 (wealthiest 1%) that only paid 3% of their income towards taxes (ITEP, 2018). The Institution on Taxation and Economic Policy attributed this irregularity to a lack of income tax, which results in the state relying heavily on sales taxes.

The poorest 20% of Washington households pay a greater share of sales, excise, and property taxes. Compared to higher-income families, lower- and middle-income families spend more of their income on taxable goods and services, thus resulting in these households paying more than their fair share of sales and excise taxes. Since affluent families do not have to pay income taxes, the taxes they do pay are relatively minimal, allowing them to accrue wealth even easier. Gentrification inflates property taxes as housing values rapidly increase, spurring displacement as long-term homeowners decide to relocate rather than pay a disproportionate amount of their fixed income on property taxes. Due to the relationship between race and income in Seattle, regressive sales, excise, and property tax policies perpetuate ongoing systemic racial injustices that deny communities of color from obtaining the same opportunities for wealth accumulation that white Americans have extensively benefited from.

Race & Social Justice Initiative

Thanks to the fortitude of racial justice advocates, the City of Seattle created the Race and Social Justice Initiative in 2004 to dismantle institutional racism in city government (SOCR, 2014). This groundbreaking citywide commitment established Seattle as the first city to formally recognize local government's role in racially disparate outcomes. Since then over 100 local and regional government jurisdictions have adopted racial equity initiatives (SOCR, 2014; GARE, n.d.). With the goal of eliminating institutionally racist policies, practices, and procedures, the initiative centers on transforming the underlying system that generates race-based disparities through racial equity. According to the City's 2035 Comprehensive Plan (OPCD, 2016):

> [The initiative's] vision is a future where race does not predict how much a person earns or their chance of being homeless or going to prison; every schoolchild, regardless of language and cultural differences, receives a quality education and feels safe and included; and African Americans, Latinos, and Native Americans can expect to live as long as white people. (p. 3)

The Race and Social Justice Initiative produced a cascading effect that reverberated across city government. All City employees take a requisite eight-hour training titled "Race: The Power of an Illusion" that addresses the historical and systemic aspects of racism. The Office of Civil Rights developed a Racial Equity Toolkit for all departments to use to ensure racially equitable outcomes within governmental proceedings, such as program planning and community engagement. City departments formed Race and Social Justice Change Teams to drive racial equity work in their respective departments. By providing a structure of accountability, the initiative has and continues to change how departments operate and build authentic relationships with local communities of color.

Seattle Public Utilities

Seattle Public Utilities (SPU), a department of the City of Seattle, adheres to the Race and Social Justice Initiative. As a public utility and the largest water supplier in Washington, SPU provides solid waste, drainage, and wastewater services to over 650,000 residential and 60,000 business customers in Seattle, as well as 1.4 million drinking water customers in the Puget Sound region (SPU, 2018). SPU has deepened its commitment to service equity—a concept for ensuring all customers fairly share the benefits and burdens of utility policies, plans, and operations.

SPU charges for drinking water, wastewater, garbage, and yard waste services once every two months. Recycling is free to encourage the practice. For a single-family household, a typical utility bill runs around $300. When a customer fails to pay their bill before the due date, a series of protocols ensue before an ultimate shutoff of water services. Accounts are considered delinquent when customers do not pay their utility bill within 21 calendar days. When the bill is 10 days past due, the customer receives an "Urgent Notice" if the balance is greater or equal to $300. At 15 days past due, SPU levies a 1% late fee on the account. At 20 days past due, the customer receives a "Final Shut-Off Notice" if the balance is greater or equal to $300. At 30 days past due, the customer may have their water shutoff at any time. To avoid a shutoff at this stage, the customer must pay 50% of their past due balance and set a payment plan for the remaining balance. If SPU shuts off the customer's water services, the customer must then pay their entire past due balance to have their water turned back on. SPU still provides solid waste and wastewater services after shutting off water services due to environmental health regulations. The average balance for a delinquent bill at the time of disconnection is approximately $1,200.

Growing costs of living and income disparities mean many SPU customers must grapple with significant affordability concerns. In 2018, the Cost of Living Index ranked Seattle as the sixth most expensive urban area in the country (CREC, 2018). A household of four needed $40,000 in 2001 to meet basic needs, but that amount nearly doubled to $75,000 in 2017 (Pearce, 2017). As necessary expenses such as housing, food, and transportation consume a greater share of household income, utility services become increasingly difficult to pay for. In 2012, Seattle had the second-highest water and wastewater utility bill out of the fifty largest cities in the U.S. (Black & Veatch, 2013). Recent internal analyses of SPU delinquent bills revealed that a $20 increase in bimonthly bills would place 56 additional customers at risk of water disconnections. Much like Washington state and Seattle taxes, utility bills are regressive, and financially constrained households must pay a greater share of their income on necessary expenses compared to wealthier households.

In 1989, SPU launched a series of water conservation efforts due to concerns that Seattle's growing population would exacerbate the water supply. These conservation programs successfully lowered total consumption by 30% and prevented the city from undergoing the extremely costly endeavor of finding a new water source. Since water demand no longer reflected population size, the utility restructured their rates to generate steady revenues with seasonal block rates. SPU bills have thereafter outpaced inflation, growing at an average rate of 6% (vs. 2.9% inflation rate) (Flory, 2019). During the "peak" season in 2019, single-family residents had two different block rates based on centum cubic feet (CCF): households were charged $6.69 per CCF when they used between 5.5 and 18.5 CCF of water and when they surpassed 18.5 CCF, the rate would jump to $11.80 per CCF. In the "off-peak" season, SPU charged $5.27 per CCF. These block rates for water, combined with $14.48 per CCF for sewer services, resulted in SPU having one of the highest water and sewer bills in the country (Black & Veatch, 2019).

After adjusting for inflation, the average residential rate per CCF had more than quadrupled between 1985 and 2015, yet median household income in Seattle had remained relatively stagnant during the same time period (Flory, 2019). Unfortunately, utility bills have no chance of going down due to multiple economic and environmental factors. Most pressingly, the water and sewer industry's greatest challenge in the coming years is replacing aging pipe infrastructure and finding the funds to do so (Black & Veatch, 2019). Laid in the early to mid-twentieth century, nationally more than one million miles of underground pipes have approached the end of their useful life of 75 to 100 years (ASCE, 2017). The American Water Works Association estimated that improving existing pipe infrastructure and matching the drinking water needs of a growing population will cost at least $1 trillion in the coming decades (AWWA, 2012). State and local governments will bear much of this financial burden since federal funding for water systems has declined since the 1970s (Congressional Budget Office, 2018). Expenses from upgrading expiring infrastructure and decreased revenue from successful conservation measures have pressured utilities to raise rates, which has then put undue pressure on low-income ratepayers.

To palliate affordability concerns, Seattle Public Utilities and Seattle City Light allow low-income customers to opt-in to the Utility Discount Program (UDP). UDP is the primary way SPU helps ratepayers keep on top of their bills. To qualify, household income must be equal to or below 70% of the Washington state median income (SPU, n.d.-b). For these income-eligible Seattle residents, utility customers receive a 50% discount on their Seattle Public Utilities bills and a 60% discount on their Seattle City Light bills. Although the utility estimated that close to 25% of Seattle households qualify for UDP, only three in ten eligible households successfully applied and received the discount.

If ratepayers require immediate help with an outstanding bill, they may qualify for the Emergency Assistance Program (EAP), which provides up to $448 towards their utility bill (SPU, n.d.-a). Ratepayers must meet all the following criteria for eligibility: 1) The property is a single-family residence. 2) Gross income is equal to or below 80% of the state median income. 3) The utility account is under the ratepayer's name. 4) The ratepayer has not already received emergency assistance during the same calendar year. However, if children under 18 years of age reside in the household, the ratepayer may receive EAP assistance twice a year. In 2018, 884 customers received utility bill assistance through EAP. Measures such as UDP and EAP provide immediate assistance to financially burdened customers but fail to address the underlying issues with affordability. As the utility continuously scales up its already costly rates, these programs may not sufficiently aid ratepayers struggling to pay their bimonthly bills.

Literature Review

The Human Right to Water

In 2002, the United Nations Committee on Economic, Social and Cultural Rights defined the right to water as "sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic uses," thereby sanctioning the human right to water into international law (United Nations et al., 2010, p. 6). The Committee expanded on the notion of water affordability by stating no individual or group should be denied access to potable water due to their inability to pay. Furthermore, the cost recovery of water and sanitation services should not be a barrier for water access or compromise anyone's ability to enjoy other human rights, such as the rights to education, food, or housing. It underlined the concept that low-income households should not disproportionately bear the burden of water and sanitation costs. The concept of water security varies widely depending on the academic field, but at the household level researchers broadly define it as "access by all individuals at all times to sufficient safe water for a healthy and productive life" (Wutich et. al, 2017). Water access relates to water security in that it refers to "the capacity to access water for consumptive purposes, including physical access, affordability, and reliability" (Jepson, 2014).

Though countries affiliated with the Organization for Economic Cooperation & Development (OECD) account for 63% of the world's gross domestic product (U.S. Mission to the OECD, n.d.), universal water access continues to allude their citizens. Martins et al., 2016 asserted that macro-assessments of affordability masked potential problems certain portions of the population face within these countries. From surveying the water security of 2,386 households in Portugal, their study found significant challenges for low-income groups, particularly those with children and large families. For low-income households with at least one child, the likelihood of affordability issues nearly tripled. The average household size was similar between low-income groups and the national estimate, but more than half of low-income households spent a disproportionate amount of their income on water despite below-average water consumption. For countries with significant income inequality, the researchers recommended that regulators and policy makers perform a comprehensive analysis of water affordability issues to understand concerns experienced by poor households.

U.S. Water Regulations

The United States has a disunified legal framework for governing water security, and laws and regulations that serve to secure safe and affordable access to water and sanitation prove ineffective in protecting the human right to water. The Clean Water Act (CWA) and the Safe Drinking Water Act (SDWA) comprise of two of the strongest federal protections for drinking water (Gaber, 2019). Designed to limit the amount of pollution in water bodies, the CWA monitors water quality, sets wastewater treatment standards, regulates discharges, and oversees permits and licenses (EPA, n.d.-a). The SDWA enforces federal drinking water health standards set by the U.S. Environmental Protection Agency (EPA) for all public water systems. However, neither of these regulations uphold all five of the United Nations' aspects of the right to water: sufficient, safe, acceptable, physically accessible and affordable (United Nation et al., 2010). In fact, they barely uphold one—safety. Violations of the safety standards for drinking water habitually occur despite the SDWA. From 1982 to 2015, health-based drinking water quality violations affected 9 to 45 million people annually (Allaire et al., 2018).

Affordability acts as a key element in guaranteeing the right to water, but no federal or state assistance programs mitigate residential water unaffordability. Instead, water utilities uphold this responsibility at their relative discretion. Many water utilities routinely disconnect water services for late payments and offer few protections for low-income populations or times of hardship. Although Seattle Public Utilities assists eligible low-income populations with the Utility Discount Program, the utility regularly shuts off water services for non-paying customers, even those enrolled in the Utility Discount Program. This stands in contrast to energy utilities, where a growing number of jurisdictions have assistance programs and policies against energy disconnections for customers with medical conditions who rely on medical electrical equipment (e.g. life support machines and nebulizers) or during extreme weather conditions when residents direly need heating or cooling (Verclas et al., 2018). Since water policies rarely focus on low-income communities, and low-income assistance programs rarely focus on water issues, the marginal intersection between the two makes for fragmented programs and limited political salience (Wescoat et al., 2007)

Measuring Water Affordability

Researchers, utilities, and governments have yet to reach a consensus on what water affordability entails, but utilities have widely adopted the EPA's benchmark of 4.5% of median household income spent on water and wastewater services (2% on water, 2.5% on wastewater) (EPA, 1995). However, this EPA standard has a fundamental flaw:

the agency originated this approach in its 1984 Financial Capability Guidebook as a way of measuring the financial capability of a *utility* to comply with regulations (EPA, 1984). The purpose of the benchmark was never meant to measure *household* affordability. Median household income factored in as one of many components to assess the economic impact upon a utility when complying with Clean Water Act regulations (EPA, 1995; 1997).

Four additional flaws weaken the EPA's metric as an appropriate gauge of affordability (Teodoro, 2018). First, it measures average residential water consumption instead of essential water use for health and sanitation purposes. Evaluating average water consumption combines customers who use only what they need with an outlier of high-volume customers. These outliers inflate average demand with activities like maintaining swimming pools and watering large lawns, which ultimately increases the cost of water utility services. Second, it reflects median income instead of low income, which takes the focus on affordability away from poor households facing the most pressing financial concerns. Similar to the research finding in Martins et al., 2016, this type of assessment obscures the affordability concerns of low-income communities, especially in areas with high-income stratifications. Third, the EPA standard doesn't account for the cost of living. Basic needs other than water, such as housing, food, and healthcare demand financial attention as well and limit the financial flexibility of a household. By not centering disposable income and focusing on the median, the EPA's approach dismisses national variations in the cost of living. Fourth, it's an "arbitrary, binary standard" (Teodoro, 2018), since crafting a hard line with the 2% benchmark eliminates nuance and simplistically marks water rates as either affordable or unaffordable. Utilities that use the EPA's method to determine water affordability continue to underestimate the financial burden of water services and obscure challenges residents face in accessing water.

Even when using this flawed method, the results from a 2017 nationwide assessment painted a bleak picture of a burgeoning crisis with water affordability (Mack et al., 2017). From analyzing a survey of 296 utility rates in 2014, researchers calculated that 11.9% of all households in the continental U.S. spent more than the EPA standard of 4.5% of their income on water and wastewater services; they predicted another 23.5% of households would find their bills unaffordable in the coming future. The researchers conservatively estimated that if utility bills continued to rise over the next five years, 35.6% of households would not be able to afford water and wastewater services. In another study on single-family residential water and sewer services, researchers found that low-income populations spent 9.7% of their disposable income or worked 9.5 hours in a minimum wage job to pay for their water and sewer bills (Teodoro 2019).

Racial Disparities in Water Security

As a country with high aggregate wealth, the international community widely assumes that the United States has water security for all its residents; indeed, most Americans don't think twice about the water they use for cooking, washing their hands, or flushing their toilets. To illustrate, a 2017 report by the United Nations Children's Fund and the World Health Organization reported the U.S. had 100% access to safe water and sanitation in urban areas (UNICEF & WHO, 2017). Yet this myth of universal access neglects areas of the country where water has turned into a luxury commodity for many low-income communities of color. In the primarily black and working-class city of Detroit, Michigan, residents paid between 3.1% to 21% of their income for water and sewer services (WPDCRC, 2016), and more than 112,000 households had their water shutoff between 2014 and 2018 (Samilton, 2019). In Philadelphia, Pennsylvania, an estimated 40% of residents had delinquent water bills in 2017 (Nadolny, 2017). Approximately one in five Philadelphians, disproportionately black and Latinx, had their water shutoff at least once between 2012 and 2017 (Frederick, 2017).

Witnessing the uneven landscape of water access in their communities, non-governmental and community-based organizations have led the research on racial disparities in water affordability. The National Association for the Advancement of Colored People (NAACP) examined the impacts of rising water rates in black communities by analyzing conditions in Baltimore, Maryland, and Cleveland, Ohio (Montag, 2019). In Baltimore, water rates bypassed the EPA's 2% affordability metric by taking up to 8% of black median income. Property liens for unpaid water bills as low as $300 occurred frequently in Cleveland's Cuyahoga County and though black residents only comprised of 30.5% of the population, approximately 65% of water liens were placed in majority-black census tracts. Comparatively, whites made up 60% of the population, but only an estimated 20% of water liens were present in majority-white neighborhoods. We the People of Detroit Community Research Collective published "Mapping the Water Crisis: The Dismantling of African-American Neighborhoods of Detroit" in 2016, which provided a systems overview of mounting water insecurity in the city. Their research found that low-income, black Detroiters paid higher rates and received harsher penalties for delinquent water bills than white, middle-income residents in nearby suburbs.

A Boston community-based organization statistically analyzed the relationship between threatened water shutoffs and racial demographics in their city using data from the Boston Water and Sewer Commission (Foltz-Diaz et al., 2014). By using bivariate regression, the researchers showed that for every 1% increase in the variable representing people of color, the rate of shutoffs increased by 1.5 per one thousand residents, thus concluding a “strong persistent relationship between race and water access.” Although the study produced compelling results, its design had limitations. The researchers analyzed threatened water shutoffs (i.e. notices ratepayers receive before having their service disconnected) rather than actual water shutoffs. They also had to estimate how many notices purely represented residential shutoffs since the dataset included industrial and commercial water accounts. Additionally, the researchers used average income and vacancy rates as proxies to determine whether the shutoff notice was related to financial struggles or a change of address. Even with its drawbacks, the report showed the value in assessing disparate impacts at the city scale.

Scholarly research connecting water affordability with race has produced contradictory results from community research findings. In a nationwide sample of utilities, researchers overall found low correlations between demographic variables and water and sewer bill affordability, barring one exception which found that larger Hispanic populations had strong negative correlations with affordable utility services (Teodoro 2019).

Racial Disparities in Water Quality

Though academic research on race and water affordability is slim, numerous studies have found racial disparities in drinking water quality. Switzer et al., 2017 analyzed 12,972 utilities in the U.S. over four years and found that the number of Safe Drinking Water Act (SDWA) violations correlated with race/ethnicity when the population was below the poverty line. Predominantly black or Hispanic low-income communities were more likely to experience poor health compliance of the SDWA by local utilities compared to similar majority-white low-income communities. While Switzer et al. believed that socioeconomic disparities in drinking water quality were not likely an act of overt, conscious racial bias, the results of the study unveiled the impacts of structural racism that manifests in every system when left unchecked.

McDonald et al., 2018 analyzed initial and repeat SDWA violations by 58,031 Community Water Systems from 2011 to 2015. The SDWA defines Community Water Systems (CWS) as regulated water systems that serve a minimum of 15 service connections or at least 25 full-time residents year-round (EPA, n.d.-b). The researchers found that lower socioeconomic status populations and communities of color faced exposure to poor water quality from both initial and repeat drinking water violations. Another report by the Pacific Institute found that counties in California with the highest number of drinking water violations had higher percentages of Latinx communities (Cooley et al., 2016).

Flint, Michigan made headlines when officials declared its water crisis a state and federal emergency in 2016 (Kennedy, 2016). The cost-cutting measure to switch its water source from Lake Huron to the Flint River in 2014 introduced lead-contaminated water into the homes of the majority-black city, where over 40% of the population lived below the poverty line (Butler et al., 2016). A massive public health crisis ensued, with at least twelve related deaths and thousands of children exposed to the long-term effects of lead poisoning (Ruckart et al., 2019). The contaminated water was also some of the most expensive in the country, with households spending more than twice as much on their water bill than the average home served by a public utility in 2015 (Food & Water Watch, 2016).

Due to the lack of federal and state regulations to establish universal water security, a foundational legal basis for water rights does not exist. Utility rates will continue to increase and thereby aggravate affordability concerns. Unless utilities make concerted efforts to establish affordability frameworks in accordance with the human right to water, households will struggle to maintain payments, and the number of water shutoffs will rise.

Methods

This research explored the relationship between Seattle Public Utilities' (SPU) single-family residential water shutoffs and population demographics. Water shutoff data consisted of disconnection incidents within city limits from 2008 through 2019 collected by SPU. Population data on race, median household income, and poverty levels were obtained from the American Community Survey five-year estimates. My methods included ordinary least squares regression, geographically weighted regression, and GIS mapping. Water shutoffs served as the dependent variable while the percent people of color, median household income, and the percent of the population below the poverty line acted as independent variables. Because structural racism is embedded in every system in the U.S., I hypothesized that a connection between water shutoffs and race existed and disconnections occurred more frequently in Seattle neighborhoods with large populations of people of color.

Seattle Public Utilities Data

Water shutoff data emerged from information recorded by SPU Customer Service Branch's software databases: Customer Care and Billing (CCB) and Customer Information Data System (CIDS). SPU Customer Service Branch call center representatives recorded customer data with CIDS from 2006 through 2015 before migrating to CCB, since the software developer stopped supporting CIDS software. Along with customer account details, the databases stored information on service connections, payment histories, service disconnections, and other aspects of the customer account. Because CCB and CIDS data contained sensitive information about ratepayers, only designated employees with security clearance had direct access to the databases. The combined CCB and CIDS water shutoff data spanned from January 2008 through July 2019.

As with any customer activity, when a water shutoff occurred the incident was logged into the corresponding utility account. Since a residence may have had more than one shutoff, each water shutoff was recorded as its own incident. Each utility account contained an associated address, which allowed mapping of the incidents. This research only analyzed single-family residences as opposed to multi-family apartment complexes and commercial customers.

Seattle Demographics

SPU has never collected and stored demographic information about its customers, such as race/ethnicity, household income, or family size, and publicly accessible racial demographic data at the household level did not exist. Therefore, I obtained population estimates from the U.S. Census Bureau's American Community Survey (ACS) five-year estimates. I demarcated demographic data by census block group, which was the smallest geographic unit provided.

According to 2018 ACS five-year estimates (Table 2), Seattle's population was 64.5% white and 35.5% persons of color (OPCD, n.d.). Because the percentages for each non-white racial/ethnic category were low, I combined them for statistical comparison with the white population.

Table 2

2018 ACS Racial Demographic Estimates

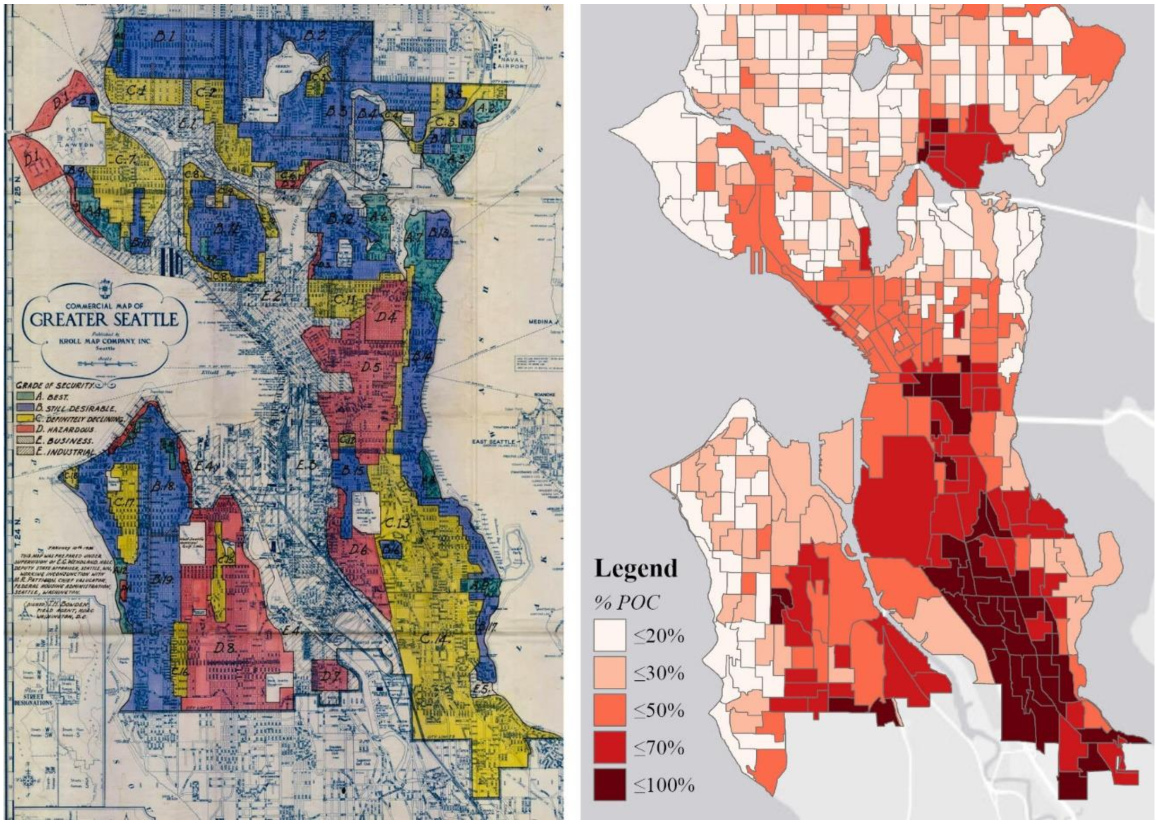
Race/Ethnicity	Percent of the Population
American Indian & Alaska Native	0.5%
Asian	14.9%
Black or African American	6.8%
Hispanic or Latino ethnicity	6.6%
Native Hawaiian & Other Pacific Islander	0.3%
Other race	0.3%
Two or more races	6.0%
Persons of color	*35.5%*
White	64.5%

Note. Adapted from "Race & Ethnicity Quick Statistics," by the Seattle Office of Planning and Community Development (OPCD) (n.d.). *About Seattle*. https://www.seattle.gov/opcd/population-and-demographics/about-seattle#raceethnicity

As seen in Figure 1 (Nelson et al., n.d.), historically redlined neighborhoods (i.e. Delridge, Highland Park, South Park, Central District, and Beacon Hill) had relatively high percentages of people of color in 2018, though more and more people have experienced displacement from gentrification. Rainier Valley and Rainier Beach had racially diverse communities as well, with large immigrant and refugee populations (Johansson, 2013; Scher, 2017). As a generalization, neighborhoods with high percentages of people of color reside in the south end of Seattle, removed from the waterfronts.

Figure 1

1936 Redlining Map & 2018 Percent People of Color (%POC) by Census Block Group



Note. Redlining map (left) reprinted from "Mapping Inequality: Redlining in New Deal America," by Nelson et al. (n.d.). https://dsl.richmond.edu/panorama/redlining/#loc=11/47.589/-122.355&city=seattle-wa&text=downloads

In conjunction with data on race, I collected ACS estimates on median household income and the percent of the population below the poverty line by census block group. I chose median household income as a dependent variable since utilities and academic studies commonly used this measure in assessments of affordability (Mack et al., 2017). The percent of the population below the poverty line represented low-income populations impacted by high utility rates. These economic measures served as proxies for financial health to gauge a neighborhood's ability to pay utility bills. The primary purpose of the variables was to assess their relative strength compared to race in influencing water shutoff frequency.

Regression

This study utilized ordinary least squares (OLS) and geographically weighted regression (GWR) to statistically analyze the independent and dependent variables and clarify the narrative visualized by the maps. OLS served as a primer to evaluate the overall relationship between water shutoffs and ACS demographic variables. GWR then offered a localized approach by including the spatial dynamics of variables such as distribution and physical proximity. Because the water shutoff data spanned twelve years, I divided the data into two categories for more accurate comparisons with ACS estimates. Water shutoffs from 2008 to 2013 were analyzed with 2013 ACS estimates and water shutoffs from 2014 to 2019 were analyzed with 2018 ACS estimates.

GIS Mapping

I used Esri's ArcMap software for mapping and spatial analysis functions. GIS professionals in Seattle city government also use ArcMap for mapping processes, which would conveniently allow them to follow and update the workflow from this research. Water shutoff data was geocoded to create point features of each incident. After mapping all shutoffs, I mapped incidents by reconnection times, UDP enrollment, and the number of shutoffs per residence. The frequency of water shutoffs per census block group (normalized by acres within the block group) was calculated to compare with demographic information.

I used Kernel Density and Optimized Hot Spot Analysis tools to spatially analyze the datasets. Commonly referred to as "heat maps," the Kernel Density tool displayed where data points were concentrated within a given area by measuring the density of disconnections throughout the city. The Optimized Hot Spot Analysis tool calculated statistically significant clustering of water shutoff incidents which resulted in "hot" or "cold" spots in the data. This visualized where water shutoffs occurred at higher or lower than expected rates.

Along with the Kernel Density and Optimized Hot Spot maps, I created bivariate choropleth maps. Choropleth maps display the distribution of a phenomenon using color gradations, such as the map in Figure 1 showing the percent people of color by census block group. Typically, choropleth maps exhibit a singular variable, but as the name implies bivariate choropleth maps combine two variables simultaneously into one map. Similar to how I divided the datasets for the regression analyses, I created one map of water shutoffs between 2008 to 2013 with 2013 ACS racial demographics, and another map of water shutoffs between 2014 to 2019 with 2018 ACS racial demographics. Bivariate choropleth maps allow a clearer portrayal of the spatial relationships between two variables than side-by-side comparisons of two univariate maps.

Results

Descriptive Statistics

From January 2008 through July 2019, there were 25,808 water disconnections at single-family residences within Seattle. Because the CIDS and CCB databases used different identifiers and codes for shutoff incidents, tracking the number of shutoffs by customer account was not feasible. To bypass this issue, I calculated the number of shutoffs per residence. In Table 3, 7,885 addresses had their water shutoff once during this time period. Another 5,211 addresses had their water shutoff multiple times, ranging from two to twenty-seven shutoffs.

Table 3

Number of Water Shutoffs per Residence

Number of Water Shutoffs	Number of Residences
1	7,885
2	2,490
3	1,082
4	602
5	386
6	212
7	141
8	92
9	61
10 to 27	145

Since there may have been more than one account holder per residence during the study period (e.g. one customer moved out of the residence and another customer moved in), assessing the number of shutoffs by address does not guarantee that a singular account holder had multiple shutoffs at an address location. Conversely, an account holder may have moved residences during the study period and had shutoffs at each location. Despite these misgivings, assessing the number of shutoffs by address offered an estimate of customers facing chronic financial hardship.

Out of the 25,808 total shutoffs, there were 1,356 incidents where the account holder was enrolled in the Utility Discount Program (UDP) when the disconnection occurred. Approximately half of the incidents with UDP enrollment had between two to fourteen shutoffs per address.

Table 4 shows the length of time between water shutoffs and reconnections per incident. Thirty-seven percent of incidents had reconnections within 24 hours. However, the majority of incidents took longer than one day to reconnect, with almost a third of reconnections lasting longer than one week. The longest disconnection period was 1,673 days.

Table 4

Water Shutoffs by Length of Time

Length of Disconnection	Percent of Incidents
≤24 hours	37%
>1 and ≤2 days	17%
>2 and ≤7 days	17%
> 1 week	29%

Ordinary Least Squares (OLS) Regression

Table 5 contains the OLS results, which evaluated the independent variables (percent people of color, median household income, and percent of the population below the poverty line by census block group) in relation to the dependent variable (water shutoff frequency) (see Tables 7 & 8 in Appendices for detailed summaries). With water shutoffs between 2008 and 2013, the three independent variables had a weak, positive relationship—combined, they explained 28% of the variance in water shutoffs. With water shutoffs between 2014 and 2019, the independent variables had an even weaker relationship—combined, they accounted for 16% of the variance in water shutoffs. Despite the low values, the percent people of color had the highest adjusted R^2 out of all the variables in both datasets, with median household income and the percent of the population below the poverty line close to or equal to zero.

Table 5

Ordinary Least Squares Regression Adjusted R^2 Results

ACS Demographic Variables	2013 ACS & 2008–2013 Shutoffs	2018 ACS & 2014–2019 Shutoffs
% People of Color (%POC)	0.21	0.09
Median Household Income (MHI)	0.00	0.00
% Below the Poverty Line (%BPL)	0.00	0.01
%POC & MHI & %BPL	0.28	0.16

Geographically Weighted Regression (GWR)

GWR results are displayed in Table 6 (see Tables 9 & 10 in Appendices for detailed summaries). GWR generated local models that evaluated the spatially varying relationships between the independent variables (percent people of color, median household income, and percent of the population below the poverty line by census block group) and dependent variable (water shutoff frequency). With the percent people of color as the only independent variable for both 2008–2013 water shutoffs and 2014–2019 water shutoffs, the adjusted R^2 values were 0.51, revealing that the percent people of color explained 51% of the variance in water shutoffs. This was a dramatic increase from the adjusted R^2 of 21% and 9% from the OLS regression. When all three independent variables were combined, the variances were 0.55 for 2008–2013 water shutoffs and 0.49 for 2014–2019 water shutoffs, again a prominent leap from the OLS results of 0.28 and 0.16, respectively. Similar to the outputs from OLS, the percent people of color had the highest adjusted R^2 out of all the variables.

Table 6

Geographically Weighted Regression Adjusted R^2 Results

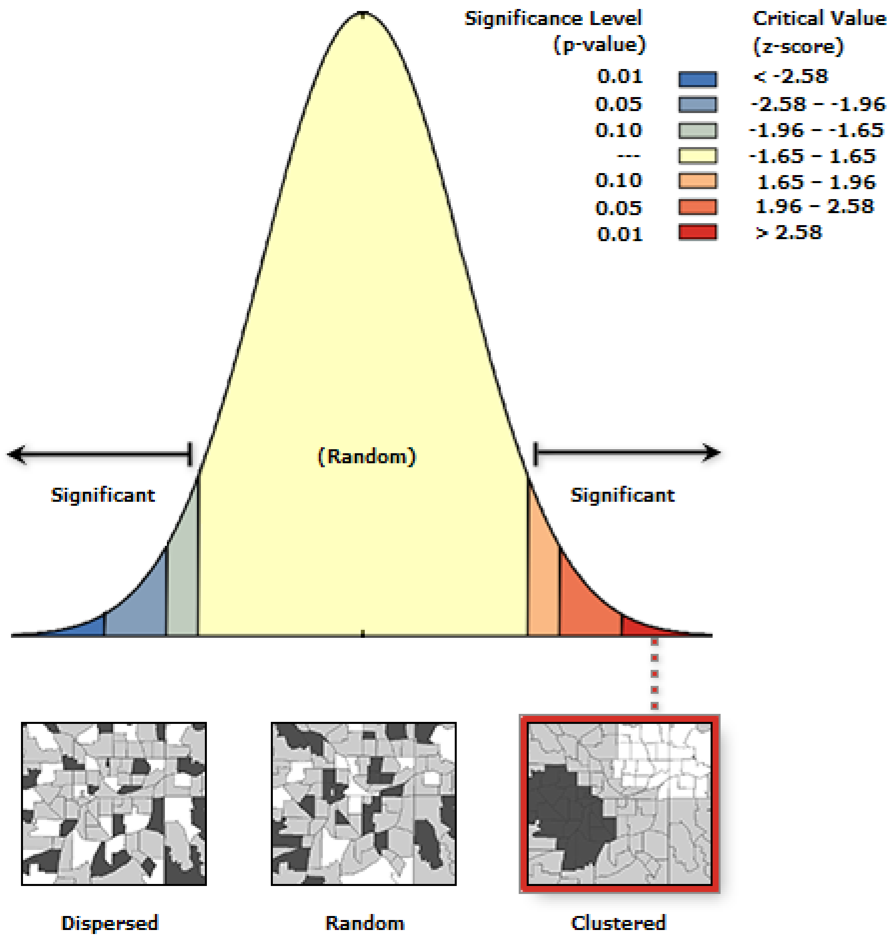
ACS Demographic Variables	2013 ACS & 2008–2013 Shutoffs	2018 ACS & 2014–2019 Shutoffs
%POC	0.51	0.51
%POC & MHI & %BPL	0.55	0.49

Spatial Analysis & GIS Mapping

Spatial autocorrelation was calculated using Global Moran's I in ArcMap (Figure 2), which analyzed the patterns within water shutoff frequencies per census block group to determine whether they were clustered, dispersed, or random. The tool produced a z-score of 26.75, meaning water shutoff frequencies per census block group were clustered. The probability that the clustering was due to random chance was less than 1%.

Figure 2

Spatial Autocorrelation (Global Moran's I) Results



The Kernel Density map of all water shutoffs from 2008 to 2019 (Figure 3) revealed that disconnections occurred most often within neighborhoods in the south end of Seattle. Specifically, shutoffs were most prominent (in red and orange) in the Central District, Beacon Hill, Rainier Valley, Rainier Beach, Delridge, Highland Park, South Park, and the northeastern part of Arbor Heights. These neighborhoods have large populations of people of color except for Arbor Heights, which shares a boundary with Highland Park. Additional Kernel Density maps of multiple water shutoffs per residence and reconnections that took longer than one day (Figure 4) all exhibit similar patterns of high concentrations within these neighborhoods. The map of UDP enrollment at the time of shutoff (Figure 4) displayed the most intensity in the Central District, Rainier Valley, and Rainier Beach.

The Optimized Hot Spot Analysis map (Figure 5) showed red hot spots in these neighborhoods once again. The red hot spots revealed at the 99% confidence interval where statistically significant levels of clustering took place, which indicated where water shutoffs occurred at higher than expected rates. The blue cold spots illustrated where water shutoffs occurred at lower than expected rates, and they appeared predominantly in the north end of Seattle along waterfronts. Cold spot neighborhoods included Capitol Hill, Madison Park, Laurelhurst, Wedgwood, Queen Anne, Magnolia, and Broadview, all of which were majority-white.

Figure 3

Density Map of All Water Shutoffs from 2008–2019

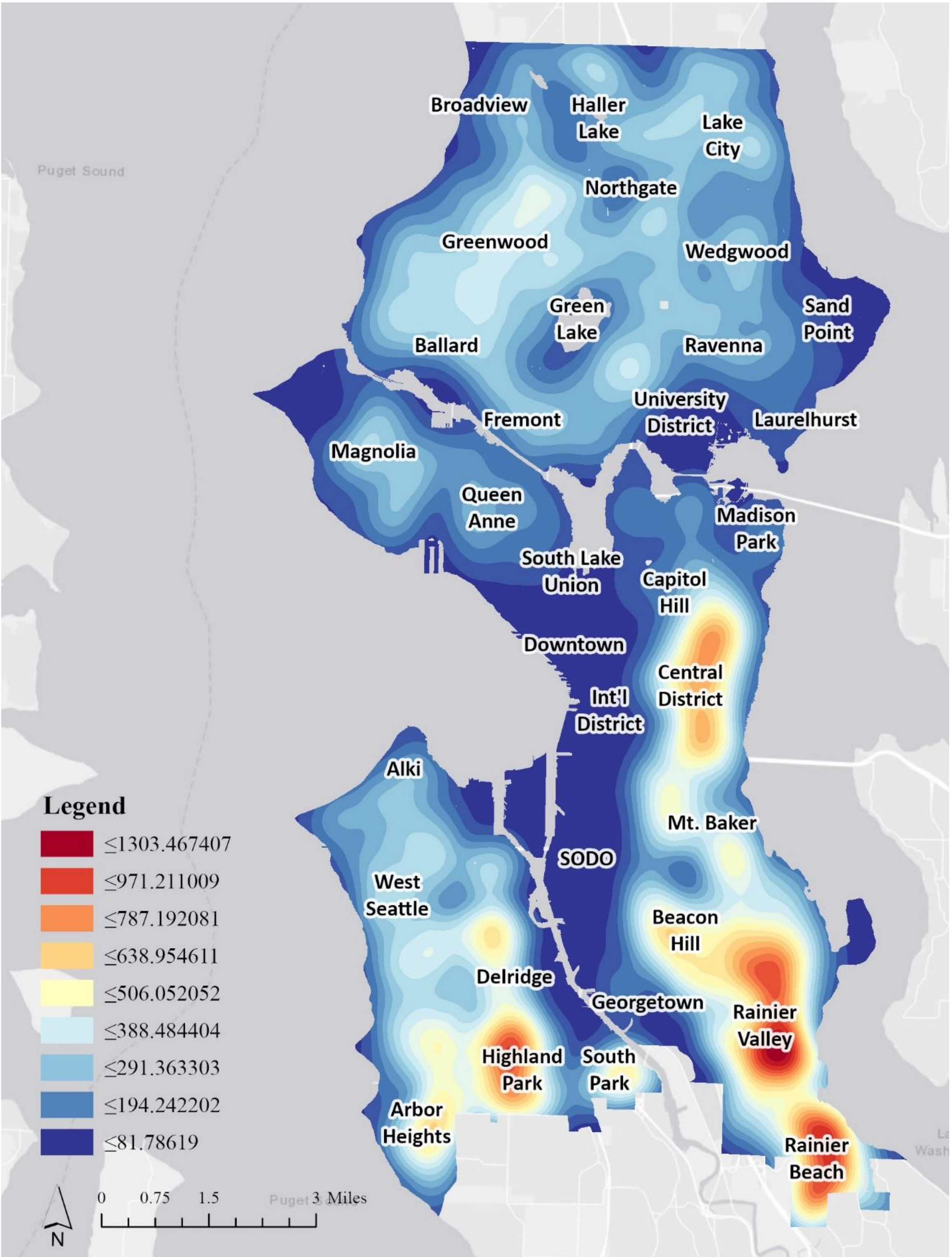


Figure 4

Maps of Multiple Shutoffs, Lengthy Reconnections, and UDP Enrollment

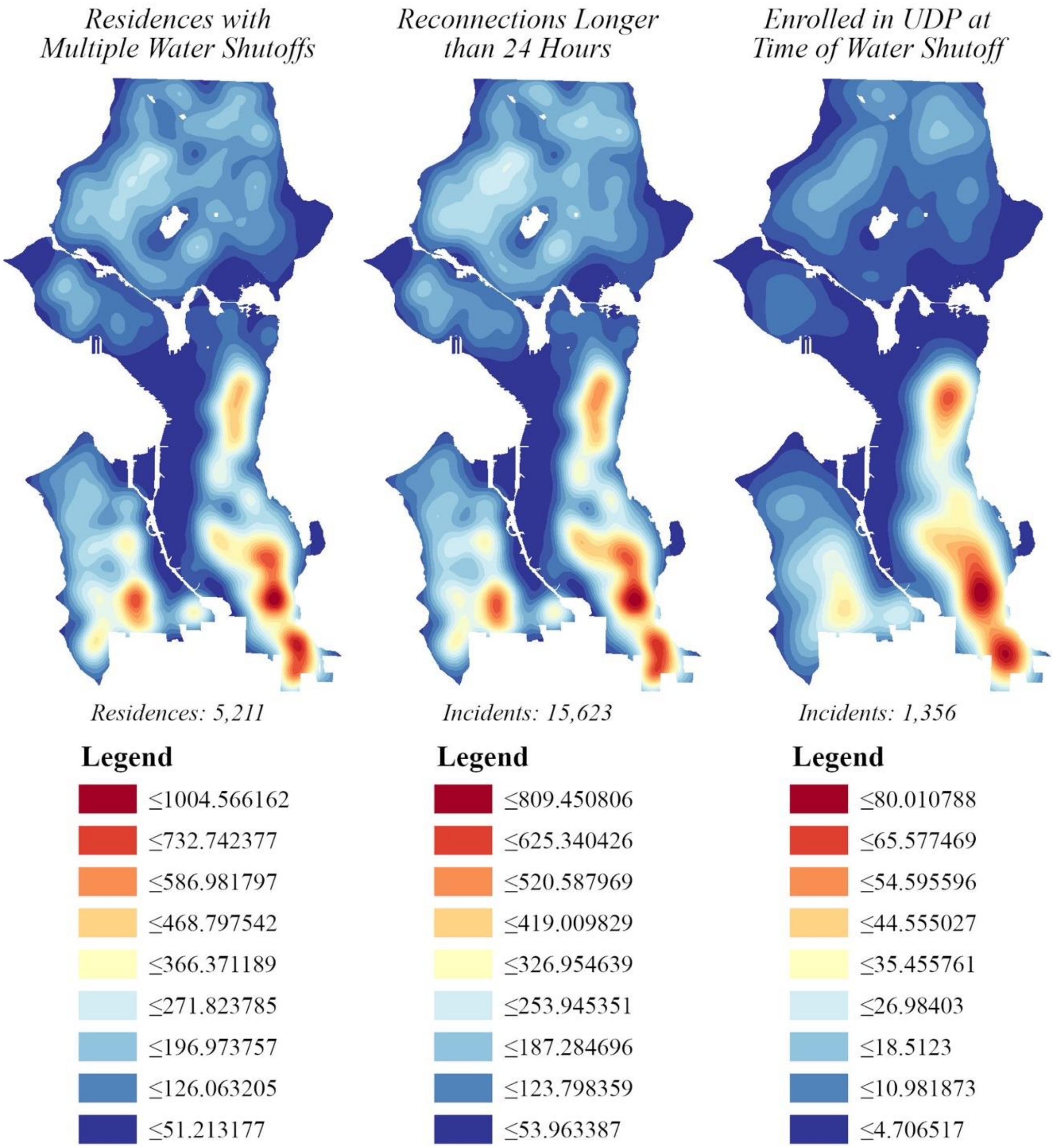
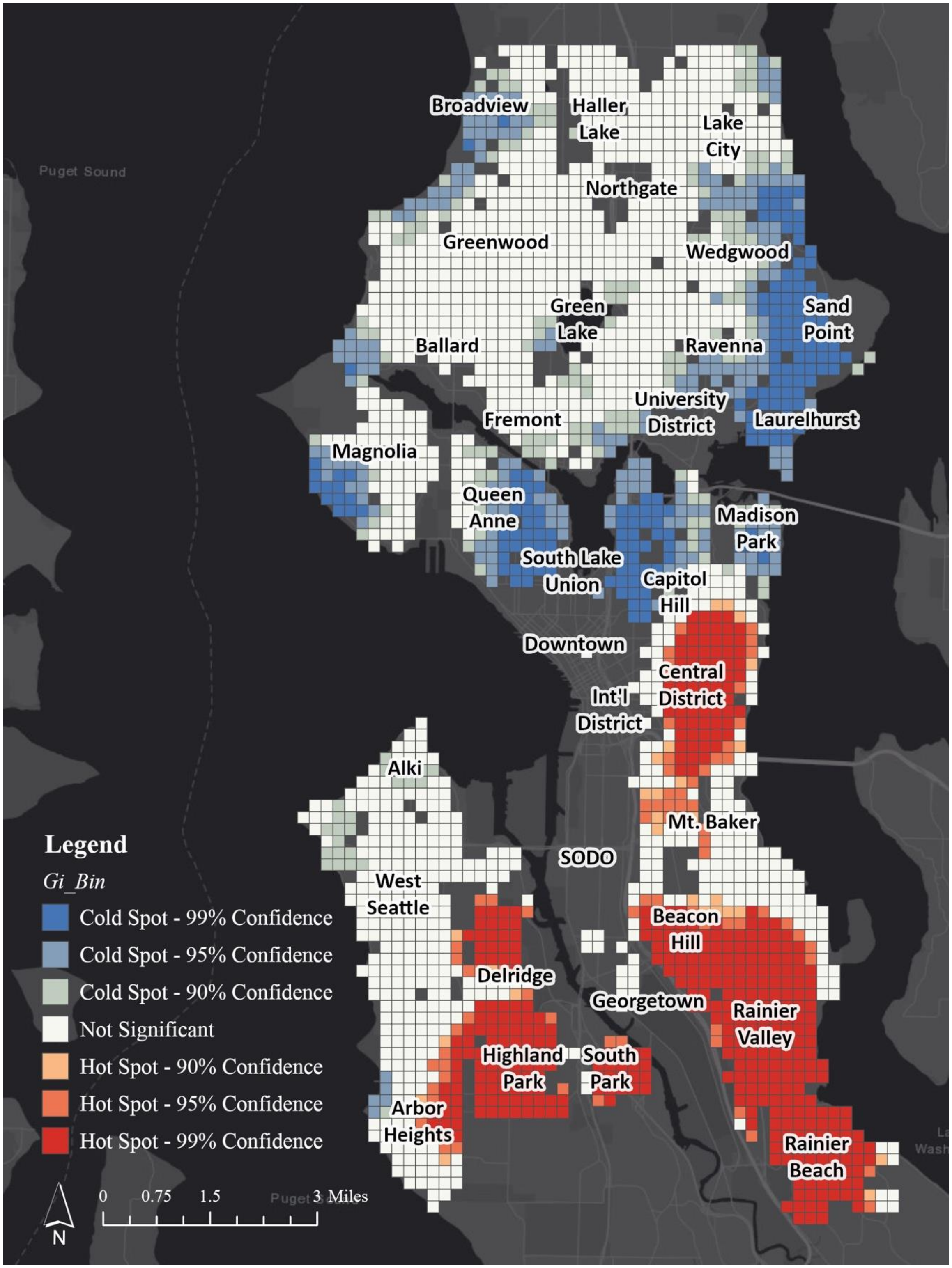


Figure 5

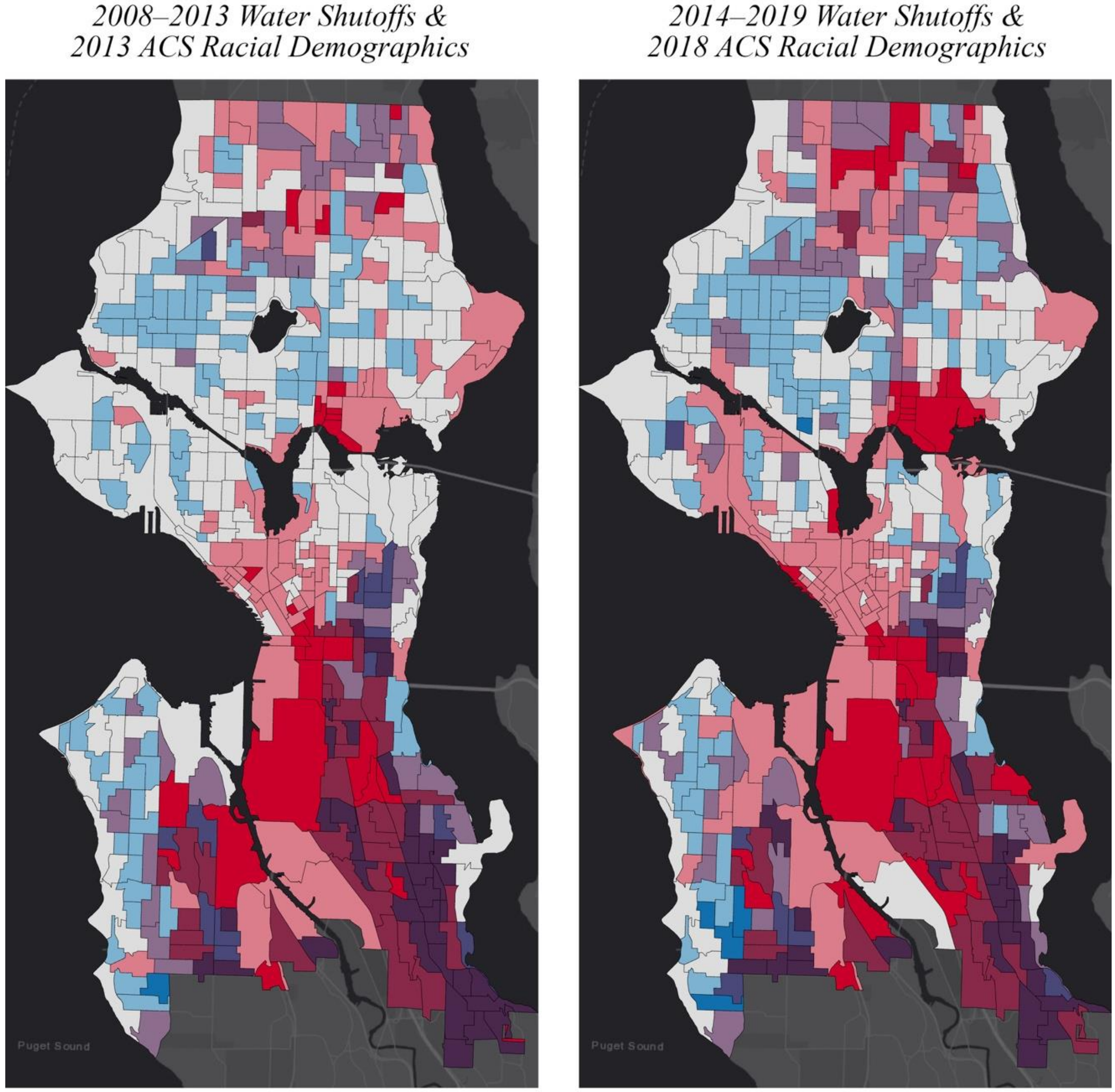
Hot Spot Analysis Map of All Water Shutoffs from 2008–2019

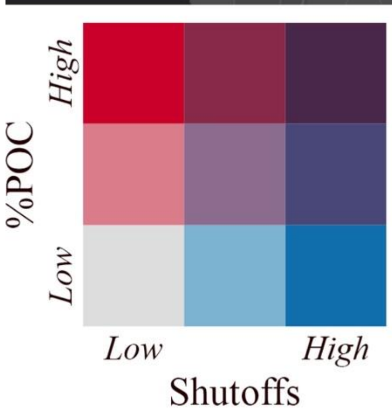


The bivariate choropleth maps (Figure 6) visualized the relationship between the percent people of color and water shutoff frequency by census block group. The map of shutoffs between 2008 to 2013 had 37 block groups with high percentages of people of color and high shutoff frequencies, while only one block group had high percentages of whites and high shutoff frequencies. In addition, 152 majority-white block groups had low shutoff frequencies while only 30 majority POC block groups had low shutoff frequencies. The map of shutoffs between 2014 to 2019 had 32 block groups with high percentages of people of color and high shutoff frequencies and 5 block groups with high percentages of whites and high shutoff frequencies. Furthermore, 104 block groups were majority-white with low shutoff frequencies, compared to 37 majority POC block groups with low shutoff frequencies.

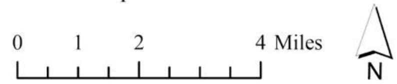
Figure 6

Bivariate Choropleth Maps





Bivariate choropleth maps illustrate the relationship between two spatially distributed variables simultaneously onto a single map. The map on the left displays the relationship between 2008–2013 water shutoffs with 2013 ACS racial demographics. The map on the right displays the relationship between 2014–2019 water shutoffs with 2018 ACS racial demographics. Census block groups delineate the data boundaries. Dark purple areas show block groups with high percentages (>50%) of people of color and high shutoff frequencies. Navy blue areas show block groups with low percentages of people of color (>75% white) with high shutoff frequencies.



Discussion

The regression results showed the influence of other explanatory variables not captured in the research. Missing variables made it difficult to fully grasp the proportional influence the study's explanatory variables had on water shutoff frequency. Independent variables related to Seattle Public Utilities' billing system could have influenced statistical power, since the probability of a shutoff may correlate with the average amount charged each billing cycle per customer (i.e. the higher the utility bill, the higher the chances of a shutoff). Due to the unavailability of this information at the time of the study, I suggest future research evaluate billing and financial data at the customer level along with water shutoffs.

The percentage of people of color by census block group contributed to water shutoffs but did not manifest as a key indicator of why disconnections happened. Instead, the percent people of color added to the explanatory power of water shutoff frequency as a secondary variable. The proxy measures of household finances per census block group, median household income and the percent of the population below the poverty line, ineffectually explained the variance in water shutoffs. Since they performed relatively poorly compared to the percent people of color, this opened the realm of possibilities that external influences outside of purely financial measures contributed to water disconnections.

The outputs from ordinary least squares and geographically weighted regression revealed an interesting quality about water shutoffs from the last decade: geography played a pivotal role in the frequency of water shutoffs. By weighing in spatial dynamics into the regression analysis, the coefficient of determination approximately doubled.

More so than the number of people of color, people below the poverty line, and median household income per census block group, neighborhoods themselves influenced the likelihood of a water shutoff. The location of a single-family residence relative to certain neighborhoods was strongly correlated to the likelihood of disconnections. The Central District, Beacon Hill, Rainier Valley, Rainier Beach, Delridge, Highland Park, South Park, and Arbor Heights had the highest frequencies of water shutoffs. All these neighborhoods, except for Arbor Heights (which is adjacent to Highland Park), had large populations of people of color.

The geographically weighted regression results and maps indicated how these neighborhoods influenced the probability of disconnections—the chances of a shutoff increased the closer a residence was to these neighborhoods, while greater distances lowered the likelihood. This may explain how the majority-white neighborhood of Arbor Heights had high frequencies of water shutoffs in the northeastern corner of the region since the area shares boundaries with neighborhoods that have large communities of color. Cold spots within the Optimized Hot Spot Analysis map alternatively revealed where water shutoffs happened with significantly less frequency in the city. Lining the waterfronts in the north end of Seattle, water shutoffs occurred with less statistically significant frequency in affluent, white neighborhoods. Though majority-white neighborhoods experienced disconnections, these shutoffs tended to be episodic, while majority POC neighborhoods tended to experience chronic disconnections.

The bivariate choropleth maps indicated wide disparities between majority POC and majority-white block groups. There were significantly higher counts of majority POC block groups with high frequencies of shutoffs compared to majority-white block groups.

Also, the total number of majority-white block groups with low water shutoff frequencies greatly outnumbered majority POC block groups. When comparing the two maps, the more recent map showed less dark purple block groups representing high shutoff frequencies and high percentages of people of color along Beacon Hill and Rainier Valley. Rather than viewing this as an improvement, I speculate that the decreased intensity was due to the displacement of residents of color. With gentrification and escalating costs of living, low-income people of color have lost ground in their historical neighborhoods, leading to a migration south outside the boundaries of Seattle.

The percent people of color, median household income, and population below the poverty line were important factors to investigate, but the geography of water shutoffs to certain neighborhoods provided profound insight on disconnections rates. Living within or near neighborhoods of color in the south end of Seattle culminated in dense concentrations of water shutoffs. Although the actual percent change in people of color had weak positive relationships with water shutoff frequency in the ordinary least squares regression, the importance of place as seen from the geographically weighted regression and maps indicated how race still influenced disconnections. Structural racism shaped neighborhood segregation and affected where communities of color live in Seattle. It is no coincidence that water shutoffs happen with more intensity in these neighborhoods due to the inextricable link between race, income, and wealth in the city. The outcomes of this study offered a look into who could afford to pay their utility bills, and the results were not color-blind.

Recommendations

Seattle Public Utilities (SPU) already has commendable measures in place to assist ratepayers struggling to pay their bills. In 2019, SPU significantly reduced reconnection fees, charging far below cost recovery. The utility gives ample notice to customers in danger of receiving a disconnection and notifies ratepayers if they are eligible for the Utility Discount Program and Emergency Assistance Program. Out of the 25,808 water shutoffs that occurred during the study time period, only 1,356 incidents consisted of those where the account holder was enrolled in Utility Discount Program at the time of disconnection. Without the program, there may have been many more water shutoffs. However, there is always room for improvement. This study provides five recommendations, listed in order of feasibility:

1. *Payment plans*: Although customers can establish payment plans when they fall behind on their bill, this option is not available after their water gets disconnected. Following a water shutoff, the customer must pay their delinquent balance in full before the utility reconnects their water service. Customers that need payment plans the most are those who have experienced water shutoffs and are struggling to gather funds to turn their services back on. The majority of water shutoffs in this study took longer than 24 hours to reconnect, meaning customers spent days without using water for basic needs. SPU must extend payment plans to customers with water shutoffs for faster reconnections.
2. *Monthly billing*: Instead of bimonthly billing, the utility could switch to monthly billing since smaller payments on a more frequent schedule may be more manageable for ratepayers. Numerous Customer Service Branch representatives

who directly connect with ratepayers have recommended this measure, but it has still not been implemented.

3. *Customer demographic data*: To form robust plans and policies on utility rate affordability, delinquent bills, and water shutoffs, the utility must collect customer demographic data to ensure equitable delivery of services. This study formed a preliminary analysis of water shutoffs but is limited by the lack of customer data. Demographic data should include race/ethnicity, household size, household income, preferred languages, age, and other critical pieces of information that would allow the utility to assess and eliminate disproportionate impacts and additional burdens on systemically discriminated populations, especially low-income communities of color. SPU already has the capacity to gather and save this data but does not currently do so. Collecting and analyzing these types of information along with utility data would benefit SPU in a myriad of ways, from guiding policy and planning decisions, measuring program success, and developing targeted outreach and communications for programs such as the Utility Discount Program. Though granular customer information would not be publicly disclosed, the utility could establish a precedent and share this information with Seattle City Light and other city government departments so that they too can provide racially equitable services.
4. *Sharing data*: My research covers one utility in one city, but structural racism has roots throughout the United States. Public utilities all over the country must be willing to share information and collaborate with one another to tackle growing issues with affordability and address inevitable disparate impacts. If I didn't have

an internship with SPU, I would never have gotten access to water shutoff data. I was hard-pressed to find this type of information from other utilities. Utilities have a responsibility to the communities they serve and should regularly disclose water shutoff reports to the public. Affordability concerns will continue to grow as utilities deal with rising costs from replacing aging infrastructure and mitigating climate change impacts since these expenses will eventually pass down to ratepayers. Until federal and state governments formally recognize the human right to water, allocate funds for subsidization, and take actionable steps toward addressing water affordability, the responsibility falls upon public utilities to ensure affordability.

5. Even though federal and state legislation may lag on recognizing water as a human right, Seattle Public Utilities can proactively establish this tenet as a core value by eliminating water shutoffs altogether. At the bare minimum, the utility can establish shutoff protections for households with children, seniors, and persons with disabilities. Disconnecting and reconnecting water services expends time and labor, resulting in costs that could be better spent on humane alternatives. Amirhadji et al., 2013 recommended administering progressive rate structures through three combinable mechanisms to ensure water affordability and avoid shutoffs: lifeline rates, financial needs testing, and graduated block rates. Lifeline rates involve providing enough water services to cover essential human needs per household at nominal to no cost. Financial needs testing would allow the utility to set lower rates for customers with incomes below the affordability threshold. Graduated block rates establish tiered prices for water as consumption increases,

so customers who consume significantly higher volumes of water pay a higher price per unit. SPU can adjust its residential tiered pricing structure so that the first tier is a lifeline rate, where services covering basic human needs are offered at no cost. The subsequent tiers can charge at an exponential rate based on income and consumption levels, which would equitably disperse financial costs while promoting water conservation. Philadelphia pioneered this approach of implementing income-based water bills with their Tiered Assistance Program, which began in 2017 (Graham Sustainability Institute, 2017). Eligible households have their monthly bill priced between two to four percent of their income. Additionally, program participants receive information on water conservation, free leak detection tests, and low-flow plumbing fixtures. The utility also suspends payments in arears and forgives past debts when residents pay their monthly balance on time for two years.

Conclusion

Previous research analyzed water affordability primarily through financial variables, but solely evaluating measures like income oversimplifies a multi-dimensional issue. Since the United States has a racialized society with deeply rooted disparities based on racial identity, this research reexamined the contextual landscape of water shutoffs by inquiring into the nature of disconnections and racial demographics in Seattle, Washington.

Seattle Public Utilities performed 25,808 water shutoffs between January 2008 and July 2019. The relationship between disconnections and American Community Survey racial demographic data, along with proxies of financial health (i.e. median household income and the percent of the population below the poverty line) produced weak, positive coefficients of determination when calculated with ordinary least squares regression. However, the adjusted R^2 approximately doubled when calculated with geographically weighted regression. The stark difference between these two coefficients of determination revealed the prevailing influence of geography within the data, denoting that structural issues tied to neighborhoods played a heavier hand than the actual value of the percent people of color, median household income, or the percent of the population below the poverty line.

Mapping water shutoffs resonated with regression findings, as persistently high concentrations of water disconnections illuminated neighborhoods of color in the south end of Seattle. The Central District, Beacon Hill, Rainier Valley, Rainier Beach, Delridge, Highland Park, South Park, and the northeastern part of Arbor Heights irrefutably claimed the highest frequencies of disconnections. These neighborhoods had large populations of people of color except for Arbor Heights, which shares a boundary east of Highland Park. Not only did these neighborhoods exhibit the largest overall shares of disconnections, but also the highest concentrations of residences with multiple shutoffs and accounts with reconnections that took longer than twenty-four hours. Though the utility shutoff customers' water throughout the city, disconnections in majority-white neighborhoods occurred intermittently with much less frequency than the overwhelming number majority POC neighborhoods chronically endured.

These neighborhoods are not hot spots by random chance. Housing policies and practices limited access to capital and credit for people of color, with long-lasting influences on racialized residential patterns, neighborhood economic health, and household wealth accumulation. Gentrification, displacement, and regressive taxes add to the list of obstacles poor communities of color in Seattle must overcome. With its current rate structure, low-income residents of color disproportionately bear the cost of Seattle Public Utility services. I provided five recommendations for Seattle Public Utilities, and all utilities in general, to rethink data processes and reform their billing structures to equitably provide water services. Seattle Public Utilities publicly prides itself as a community-centered utility acting in accordance with the Race and Social Justice Initiative. However, present rate structures and affordability measures continue the legacy of uneven burdens on low-income communities of color, and projected utility rate increases will aggravate these conditions. Utilities must address this gap between water rates and customers' abilities to pay because regardless of race, everyone deserves the right to safe, affordable water.

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Appendices

Table 7

Ordinary Least Squares Regression Results: 2013 ACS & 2008–2013 Water Shutoffs

	% People of Color (%POC)	Median Household Income (MHI)	% Below the Poverty Line (%BPL)	%POC & MHI & %BPL
Adjusted R^2	0.21	0.00	0.00	0.28
Akaike's Information Criterion	-101.16	9.20	10.79	-145.90
Jarque-Bera p-value	0.00	0.00	0.00	0.00
Koenker (BP) Statistic p-value	0.00	0.00	0.00	0.00
Variance Inflation Factor	1.00	1.00	1.00	1.78

Table 8

Ordinary Least Squares Regression Results: 2018 ACS & 2014–2019 Water Shutoffs

	% People of Color (%POC)	Median Household Income (MHI)	% Below the Poverty Line (%BPL)	%POC & MHI & %BPL
Adjusted R^2	0.09	0.00	0.01	0.16
Akaike's Information Criterion	-35.57	9.66	5.16	-72.41
Jarque-Bera p-value	0.00	0.00	0.00	0.00
Koenker (BP) Statistic p-value	0.00	0.00	0.53	0.00
Variance Inflation Factor	1.00	1.00	1.00	1.83

Table 9

Geographically Weighted Regression Results: 2013 ACS & 2008–2013 Water Shutoffs

ACS2013	%POC	%POC & MHI & %BPL
Neighbors	41	52
Residual Squares	11.77	9.96
Effective Number	75.91	109.25
Sigma	0.17	0.16
AICc	-288.92	-289.15
R^2	0.59	0.65
Adjusted R^2	0.51	0.55

Table 10

Geographically Weighted Regression Results: 2018 ACS & 2014–2019 Water Shutoffs

ACS2018	%POC	%POC & MHI & %BPL
Neighbors	41	55
Residual Squares	12.06	11.11
Effective Number	76.29	101.62
Sigma	0.17	0.17
AICc	-276.37	-238.77
R^2	0.58	0.60
Adjusted R^2	0.51	0.49