SOCIAL DISORGANIZATION THEORY AND HEPATITIS C INCIDENCE

by

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ABSTRACT

A growing body of research has demonstrated that community-level factors influence health-related behaviors and outcomes. While Hepatitis C Virus (HCV) incidence is increasing, in large part due to the opioid epidemic, little is known about the ways in which community environments impact its spread. The existing literature implies that individual-level factors are not sufficient to predict rates and spread of injection-related infectious diseases; the environment is crucial in determining risk-taking and protective factors. Social disorganization theory provides a framework for examining community indicators that may be associated with HCV risk behaviors, such as injection drug use, and/or HCV incidence.

The ability to predict HCV rates using community-level indicators has significant public health value; it could allow public health officials to identify areas at risk for outbreak and could facilitate targeted prevention interventions. Syringe Access Programs (SAPs), or Needle Exchange Programs (NEPs), are demonstrated effective public health interventions that prevent the spread of HCV. With limited resources and increasing opioid use, community-level predictors could guide NEP efforts to communities with the greatest need and fewest resources.

The current study hypothesized that there is a statistically significant difference in HCV rates between neighborhoods in Pittsburgh, PA, based on indicators of social disorganization and that needle exchange utilization moderates the relationship between neighborhood social

disorganization and HCV. These hypotheses were tested using correlations and linear regressions. An exploratory analysis was also conducted to examine trends that might inform the locations of needle distribution and to provide suggestions for future research.

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1.0 INTRODUCTION

1.1 HCV AND THE OPIOID EPIDEMIC

The prevalence of opioid drug use in the United States is currently at an all-time high. Public health professionals are now describing the widespread use of opioids as "epidemic" (Rudd, Aleshire, Zibbell, & Gladden, 2016; Paulozzi, Franklin, Kerlikowske, Jones, Ghiya, & Popovic, 2012). Increases in accidental poisoning deaths, or overdose, are evidence of this epidemic; since the year 2000, there has been a 200% increase nationally in the rate of overdoses related to opioids (Rudd, Aleshire, Zibbell, & Gladden, 2016). While the overdose epidemic initially began with prescription opioids, many of the current overdoses involve illegal opioids, such as heroin and illicitly-manufactured fentanyl (O'Hara, 2016; Hulsey et al, 2016).

The opioid epidemic is reflected in Allegheny County and the state of Pennsylvania overall, as evidenced by overdose rates. In Pennsylvania in 2015, 3,383 people died from drug overdoses, a 23% increase from 2014 (Hulsey et al., 2016). Allegheny County has documented a consistent increase in overdose death rates since 2006, with deaths reaching an all-time high in 2016—635 people died from drug overdose; the majority of these deaths involved opioids (Overdose Free PA, 2017). The national shift in demographics among opioid users is also reflected in Allegheny County. In 2000, the highest opioid overdose rates in the county were among black individuals aged 45-64; as of 2013, the highest rates were among white individuals aged 18-44 (Hulsey et al., 2016). These changes are consistent with national trends (Rudd, Aleshire, Zibbell, & Gladden, 2016).

Increasing rates of opioid use are logically accompanied by increasing rates of drug injection. While there is limited surveillance ability to quantify prevalence of injection drug use versus other methods of consumption, many studies have estimated prevalence using various methodologies. These estimations are valuable from a public health perspective, as injection drug use can spread blood-borne infectious diseases. Cooper et al. estimated that between 1992 and 2002 in United States cities, the rate of injection drug use was 290 per 10,000 among black individuals and 196 per 10,000 among white individuals (2008). A 2014 study estimated the number of people who currently inject drugs at .30% of the population, or approximately 30 per 10,000 people; the same study estimated that people who have injected drugs at any point in their lives made up about 2.6% of the population, or 260 per 10,000 people (Lansky et al., 2014). Ultimately, research estimating injection prevalence versus other drug use methods is limited, and prevalence is difficult to estimate in the midst of increasing opioid use and continuously shifting intervention strategies to decrease use. However, the increase in opioid overdose suggests strongly that more and more people are injecting drugs, and opioids in particular.

The transmission of HCV is among the many health threats of injection drug use. HCV is the most common blood-borne infection in the United States, and is most often transmitted through injection drug use (Latimer et al., 2009; Amon et al., 2008; Zibbell et al., 2015). HCV is more infectious than HIV and can survive in syringes for weeks after contamination (Ciesk et al., 2010; Paintsil, Peters, Lindenbach, & Heimer, 2010). In Allegheny County, injection drug use is the primary risk factor among documented HCV infections (Allegheny County Health

Department, 2014). The prevalence of HCV among different cohorts of injection drug users has been documented between 30 and 70% (Latimer et al., 2009; Havens et al., 2013; Schulte et al., 2015; Oster et al., 2014). In 2011, Lansky et al. estimated the HCV infection rate at 43,126 per 100,000 among people who inject drugs (Lansky et al., 2014).

The increasing prevalence of injection drug use creates more opportunities for transmission of HCV and other blood-borne infections; it follows that HCV rates in the United States are increasing in the context of the opioid epidemic. Nationally, the number of acute cases of HCV reported increased each year between 2009 and 2013; the national rate overall increased from .3 per 100,000 people in 2010 to .7 per 100,000 in 2013. Among the 41 states that report HCV infections to the CDC, 12 states accounted for 68.6% of the acute cases in 2013; Pennsylvania was among these 12 states (Centers for Disease Control and Prevention, 2013). Four states reported a 364% increase in new infections among individuals 30 years old and under between 2006 and 2012 (Zibbell et al., 2015).

These trends in HCV infection affect both urban and non-urban areas. Research in non-urban areas has documented an upsurge in HCV incidence related to the opioid epidemic. In central Appalachia, increases in acute HCV are highly correlated with the prescription opioid abuse rates and increases in the number of people who inject drugs (Zibbell et al., 2015). Earlier research noted similar trends in urban areas among youth—a 2011 study documented an increase in injection drug use among youth and young adults between 1992 and 2002. Among this population, injection drug use increased from 95.64 to 115.59 per 10,000 (Chatterjee, Tempalski, Pouget, Cooper, & Cleland, 2011).

Pennsylvania and Allegheny County are documenting similar trends in HCV related to the opioid epidemic. In Pennsylvania, the HCV incidence rate increased within the 15-34 age group but decreased in other age groups between 2003 and 2010 (Boktor & Howsare, 2015). In Allegheny County, the Health Department received reports of 17,219 HCV cases between 2004 and 2013, with an overall increase in reported infections from 2004 to 2013 (Allegheny County Health Department, 2014).

Increasing rates of injection drug use have created the potential for sudden outbreaks of blood-borne diseases (particularly HCV and HIV). In 2014 and 2015, Scott County, Indiana experienced an injection-related outbreak of HIV; among the 181 cases of HIV, 92% were co-infected with HCV (Peters et al., 2016). In the wake of these cases, researchers in 2016 attempted to identify counties nationally that could be at-risk for a similar outbreak. This study used HCV as a proxy for injection drug use, and used the following county-level indicators that were associated with acute infections to estimate outbreak vulnerability in each county: drug overdose mortality, access to prescription opioids, access to care, drug-related criminal activity, prevalence of injection drug use, and socio-demographic characteristics associated with areas with higher injection drug use (van Handel et al., 2016). Three counties in Pennsylvania received vulnerability scores that exceeded the 95th percentile (van Handel et al., 2016).

These increasing rates of HCV pose significant burdens for the healthcare system as well as for infected individuals. Hospitalization rates among individuals with HCV are high compared to uninfected individuals, and prescription medications that treat and cure the infection are expensive (Teshale et al., 2016; Centers for Medicare & Medicaid Services, 2016). One observational cohort study documented all-cause admission among individuals with chronic HCV infection at 27.4 per 100 person years, compared to 7.4 among other health system patients (Teshale et al., 2016). In 2015, Medicare and Medicaid spent more on the prescription drug Harvoni, used to cure HCV, than any other single medication; the total cost spent for the year was 2.18 billion dollars for a total of 78,467 prescription fills (Centers for Medicare and Medicaid Services, 2016). The cost burden of these hospitalizations and prescription medications impact the state of Pennsylvania as well. Statewide hospital admissions for HCV cases have risen steadily and significantly from 2000 to 2013 (Boktor & Howsare, 2015). In addition, Governor Wolf's administration expanded Medicaid coverage for HCV treatment to cover all individuals with the infection, rather than only the most severe cases (Department of Human Services, 2017); this policy change will increase the number of individuals who can be treated, which will in turn increase costs.

The prevalence of opioid drug use is currently at an all-time high in the United States, as demonstrated by overdose mortality rates. Overdose rates, and drug use by projection, mimic these national trends in Pennsylvania and Allegheny County. The increasing rate of drug injection creates more potential for the spread of blood-borne disease. The changing demographics and geography of drug use means that disease rates may be less predictable than in the past; the country has already seen outbreaks of blood-borne infections in areas with historically low prevalence, as in rural Indiana. There has been much activity historically around HIV prevention; however HCV, which is much more infectious and prevalent, now poses significant potential for outbreak. If HCV prevention interventions are not scaled up and introduced in new areas, public health officials nationally and in Allegheny County will continue to witness an increasing burden of this disease on healthcare providers, payers, communities, and infected individuals.

1.2 SYRINGE-ACCESS PROGRAMS AND HCV

Syringe Access Programs (SAPs), or Needle Exchange Programs (NEPs), are evidence-based interventions to prevent the spread of HCV among injection drug users. These programs provide sterile syringes and injection supplies to drug users, a practice which has been demonstrated to decrease syringe and other equipment-sharing behaviors that can spread blood-borne diseases (Kerr, et al., 2010). SAPs have been consistently proven as an effective way to decrease the incidence of HCV and HIV among injection drug users (Abdul-Quader et al., 2013; Des Jarlais et al., 2005). These programs are also cost effective; a 2008 study estimated that a New York syringe access program saved the government $1,300 to $3,000 per client annually (Belani & Muenning, 2008). Syringe access programs are estimated to cost about $4,500 to $34,00 per quality-adjusted life year gained (QALY) (Bernard et al., 2016).

Currently, numerous policy barriers exist to widespread implementation of syringe access programs. The primary barriers are paraphernalia laws, which vary by state and criminalize the possession of injection equipment. Federal funding for SAPs has been banned and unbanned repeatedly over the last decade. As of 2015, the ban is partially lifted; syringe exchange programs may be operated with federal funds, but still may not use these funds to purchase syringes (National Public Radio, 2016). Most formal syringe access programs are permitted to operate despite these laws through the cooperation of local governments and municipalities, while other programs operate without the formal legal allowances (Hallen & Arnold, 2017). In Allegheny County in 2001, for example, the Department of Health declared a public health emergency to allow syringe access programs to operate (Mendenhall, 2001). Prevention Point Pittsburgh currently operates their syringe access program, the only SAP in Allegheny County, under authorization through an ordinance that was adopted by the Allegheny

County Council in 2008 (Allegheny County Council, 2008). However, the Pennsylvania paraphernalia law remains in effect under 35 P.S. § 780-113(a)(32 & 33).

1.3 SOCIAL DISORGANIZATION, HEALTH BEHAVIORS, AND HEALTH OUTCOMES

Social disorganization theory suggests that certain structural characteristics impact a community's social cohesion and social control. Originally proposed in the criminology literature, social disorganization theory posits that in the absence of social control and cohesion, communities will experience higher levels of crime and delinquency (Shaw & McKay, 1942). Low community economic status, residential instability, racial/ethnic heterogeneity, family disruption, and urbanization were originally used as indicators of social disorganization. These structural factors supposedly lead to fewer local social networks, more unsupervised youth, and lower organizational participation, which subsequently lead to crime and delinquency (Shaw and McKay, 1942; Sampson & Groves, 1989). Shaw and McKay also found correlations by neighborhood between juvenile delinquency and several health outcomes, including infant mortality rates, tuberculosis, and mental illness. Their research was an early exploration of the social determinants of health, as well as some of the first research to examine population-level indicators in relation to population-level health outcomes. Additional support for their theory was demonstrated by the stable rates of delinquency in neighborhoods throughout time where demographics and populations have changed significantly and frequently; this suggests that the neighborhood itself and the physical, social, and economic conditions therein are more tied to crime rates than the population (Shaw & McKay, 1942).

More recent research has continued to use community-level indicators of social disorganization to examine and predict health outcomes. Among infectious diseases, much of this community-level indicator literature has focused on sexually transmitted diseases**.** For example, Ford & Browning found that trichomoniasis incidence was associated with neighborhood-level concentrations of poverty and concentrations of African American residents; however, incidence was not associated with residential instability or immigrant concentration (2011). Burke-Miller et al. assessed HIV disease outcomes, such as CD4 count and viral load, in relation to neighborhood indicators of social disorganization; they found that neighborhood poverty and segregation were significantly associated with worse outcomes among women in urban areas living with HIV (2016). Another study tracked incidence of psychotic disorders, finding the highest associations with neighborhood-level socioeconomic level and residential mobility; other indicators in the assessment included ethnic diversity, single-person households, voter turnout, and population density (Veling, Susser, Selten, & Hoek, 2015). Community-level factors have long been studied in relation to HIV incidence rates as well (Phillips et al., 2015).

Social disorganization has also been linked to health-related behaviors. In one study, researchers found that number of sex partners was significantly related to perceptions of neighborhood-level social disorganization, as measured by self-report (Tewksbury, Higgins, & Connor, 2013). Other research has studied how neighborhood social disorganization is associated with bullying behaviors in schools, intimate partner violence, and HIV risk behaviors such as unprotected sex and needle sharing (Bradshaw, Sawyer, & O'Brennan, 2009; Browning, 2002).

As drug use is considered a criminal activity, a health-related behavior, and a significant risk for adverse health outcomes, it is unsurprising that it has also been studied as an outcome in social disorganization research. Hayes-Smith & Whaley in 2009 used three indicators of social disorganization—residential instability, ethnic heterogeneity, and low economic status—as predictors of methamphetamine use rates across school districts. They found that ethnic heterogeneity was negatively associated with methamphetamine use, contradictory to Shaw & McKay's original theory around this particular indicator (Hayes-Smith & Whaley, 2009; Shaw & McKay, 1942). Winstanley et al. found in 2007 that social disorganization and social capital at the neighborhood-level were related to alcohol and drug use, dependence, and access to treatment among school-aged youth; social disorganization was positively associated with drug use and dependence (Winstanley et al.). A study in 2011 with contradictory results also examined adolescent drinking behaviors among urban high school youth (Brenner, Bauermeister, & Zimmerman). The researchers defined their indicators as the proportion of "families with incomes of less than $15,000," "single-headed households," "unemployment," and adults with "less than high-school education." These neighborhood-level factors were not directly related to adolescent drinking behavior, which was instead attributed to peer alcohol use.

There are similarly mixed results within research that attempts to associate social disorganization indicators with adult drug use. For example, one study found no variation in the distribution of self-reported drug use and thus no association with neighborhood-level characteristics; however, visible drug activity, as measured by self-report, was associated with social disorganization characteristics (Saxe et al., 2001). Another more recent study found that neighborhood poverty, a common indicator of social disorganization, was significantly related to participants' odds of using drugs (Williams & Latkin, 2007).

Social disorganization theory has been applied to explain variation in specific behaviors that increase or decrease risk for drug-related harm among people who use drugs, such as contracting a blood-borne disease. This body of research has demonstrated that neighborhood-level social disorganization characteristics relate to the ways people use drugs and the risk-taking or risk-reducing behaviors in which they engage. A 2012 study in El Salvador found that injection setting as well as protective and risk-taking behaviors vary with type of neighborhood. For example, the type of community in which IDUs reside will impact the specific setting (e.g. public location, private residence) where they inject drugs (Dickson-Gomez, McAuliffe, Mendoza, Glasman, & Gaborit, 2012). This study did not examine syringe sharing, but did look at risk behaviors related to drug use such as transactional sex and condom use; these behaviors varied based on place of residence, further suggesting the importance of neighborhood context in infectious disease risk.

Sacks-Davis et al. studied the relationship between community characteristics and risk of HCV among prescription opioid injectors in Montreal; the authors found that syringe sharing behaviors varied among users by place of residence (Sacks-Davis et. al., 2016). Latkin, Williams, Wang, & Curry began to identify some of the pathways through which neighborhood context impacts injection behavior and subsequent health outcomes (2005). These researchers used more specific indicators of neighborhood context as predictors, including vandalism, vacant housing, drug-selling activity, robbery, assault, littering, and loitering. They found that neighborhood disorder factors relate to injection risk behavior and subsequent infectious disease rates because they impact individuals' psychological distress. Psychological distress was found to relate to injection frequency and equipment sharing, both factors that increase the risk of contracting blood-borne infections, like HIV and HCV. Bluthenthal et al. used four census-level community measures to examine syringe-sharing behaviors that pose a risk for HIV—unemployment, public assistance, household income, and race (2007). They found that neighborhood racial composition was most strongly associated with risky injection behavior—individuals residing in communities with higher percentages of African American residents were significantly less likely to share syringes.

This research based on social disorganization theory, as well as other research based on social determinants of health and behavior more broadly, provides evidence that "place" is an important component of drug users' risk behaviors. Public versus private injection and other setting factors have been demonstrated to impact injectors' abilities to practice harm reduction, as well as the likelihood of syringe sharing (Weeks et al., 2001). The setting factors that are implicated in harm reduction for Injection Drug Users (IDUs) have been grouped into the categories of urgency, privacy and hygiene (Rhodes et al., 2006). For example, the injection setting will affect the availability of sterile water to dissolve drugs, the cleanliness of the environment, and the presence of police, which can necessitate more rapid injection and less opportunity to practice harm reduction (Weeks et al., 2001). As further evidence of the importance of setting, homeless injectors have been found to use more risky injection behaviors (Galea & Vlahov, 2002).

This growing body of research indicates that individual level factors are not adequate to predict rate and geographic distribution of drug-related infectious diseases; the environment is crucial in determining risk-taking and protective factors among injection drug users. The incidence of HCV in the United States today, unlike other infectious diseases, is driven almost exclusively by injection drug use. Thus, the HCV incidence rate by community will be a function of individual factors, environmental factors that impact drug-use risk behaviors, and protective factors in the community.

1.4 HCV, COMMUNITY-LEVEL FACTORS, AND SPATIAL ANALYSIS

Spatial analysis is a common way to examine the spread of infectious diseases in public health; geographic information systems have been used to look at injection-related infectious diseases, as well as drug use behaviors that impact risk of contracting infectious diseases. Some research has incorporated social disorganization theory into the study of disease distribution, while other research has simply identified clustering of cases. A 2007 study of Sexually Transmitted Disease (STD) rates across the United States looked at poverty, race, and social capital as explanatory variables at the state level; social capital was not associated with STD rates when racial/ethnic composition was incorporated into the analysis (Semaan, Sternberg, Zaidi, & Aral, 2007). Bluthenthal and colleagues examined community characteristics associated with HIV risk behaviors among injection drug users (Bluthenthal et al., 2007). They defined explanatory community characteristics at the census-tract-level as percent African American, percent unemployed males, percent of households receiving public assistance, and median household income; percent African American was negatively associated with syringe sharing behaviors. In 2016, Conners et al. again looked at the role of the environment on drug use and sexual behaviors that place individuals at risk for HIV; these researchers used mixed methods to characterize the HIV risk environment (Conners et al., 2016). Other study methods have mapped spatial clusters of HIV cases and examined the population characteristics of the census tracts in which the largest clusters existed; researchers have identified that poverty, men who have sex with men (MSM), and drug use rates are associated with these clusters (Hixson, Omer, del Rio, & Frew, 2011).

Researchers have used limited spatial analysis methods to examine HCV, but have not examined how social disorganization might contribute to spatial patterns in the United States. A 2007 study in England found significant variation in HCV prevalence by site of recruitment, but did not look into the environmental factors that may have caused the variation (Hickman et al., 2007). In Massachusetts, researchers found significant clustering of HCV mortality and speculated there was a relationship between poverty and other community-level factors, but were unable to incorporate these factors into the research (Meyers, Hood, & Stopka, 2014). In Michigan, researchers mapped HCV co-infection with HIV by county, but did not look at socioeconomic factors of counties; counties containing urban areas had greater HIV/HCV coinfection (Butt et al., 2015). In Egypt, the country with the highest HCV prevalence, Cuadros and colleagues identified geographic clusters of high and low HCV prevalence across the country (Cuadros, Branscum, Miller, & Abu-Raddad, 2014). Egypt's HCV epidemic is not driven by drug use, however, so the generalizability of their results to other countries is limited. Researchers in the Netherlands assessed demographic and socio-economic factors associated with HCV diagnoses. They used spatial analysis methods and found significant associations between HCV risk and socioeconomic characteristics, as well as HCV prevalence differences between rural and urban areas (Kaul et al., 2015).

Much of the spatial research on HCV focuses on individual-level characteristics of people diagnosed with HCV, rather than focusing on population-level characteristics in communities with high diagnosis rates. Research that maps HCV incidence or prevalence primarily aggregates these rates at the county or state level, rather than a smaller community level. In addition, much of the existing research examines clustering of HCV, but does not examine community-level factors as potential explanations for the clustering. The small body of spatial research that incorporates drug use and risk-taking behavior often focuses on HIV rates, rather than HCV; this may be due to the longer history of HIV reporting and surveillance. Finally, most research that maps HCV in relation to community-level characteristics has been conducted outside of the United States. The variations in population characteristics and drivers of HCV infection across countries limit the generalizability of this research.

1.5 CURRENT RESEARCH

The current study fills gaps in the existing research on the geographic distribution of HCV and community-level explanatory variables related to social disorganization. The current study maps HCV within the city of Pittsburgh, Pennsylvania at the neighborhood level. Neighborhood-level indicators of social disorganization are hypothesized as explanatory variables for geographic variation in HCV. HCV has not been mapped at the neighborhood level in Pittsburgh, nor has the association between social disorganization factors and HCV rates been measured. The current study will also examine needle exchange utilization at the neighborhood level as a mechanism through which social disorganization factors relate to HCV rates. Previous research has not looked at the relationship between needle exchange utilization and HCV rate at the neighborhood level; furthermore, the rate of needle exchange utilization has never been mapped in Pittsburgh by neighborhood. The ability to predict HCV rates at the neighborhood-level using widely available indicators has significant public health value. This could allow public health officials to identify areas at risk for outbreak and could facilitate targeted prevention interventions. It could also demonstrate the value of syringe access programs within the city of Pittsburgh.

2.0 METHODOLOGY

2.1 DATA SOURCES

The data used for this research originate from four sources: Prevention Point Pittsburgh, the Allegheny County Health Department, Pittsburgh Department of City Planning, and the Western Pennsylvania Regional Data Center.

2.1.1 Prevention Point Pittsburgh: New or Returning Exchanger Forms (2015)

Prevention Point Pittsburgh is a harm reduction organization in Pittsburgh, Pennsylvania that provides needle exchange, HIV, HCV, and STD testing, overdose prevention, and other services to people who inject drugs. Prevention Point volunteers and staff collect a small amount of information from every client that visits an exchange site. The data for this project were collected in 2015, at which time Prevention Point was distributing sterile injection supplies at exchange locations in two neighborhoods, Oakland and the Hill District, while their main office was located in Wilkinsburg (their exchange sites and main office have since moved). Volunteers and staff provided supplies at the Oakland site on Sundays and the Hill District site on Wednesdays, for a total of five hours each week. Client information was collected on New Exchanger Forms or Returning Exchanger Forms. Each form included the client's anonymous, unique, six-digit code consisting of the first two letters of the client's mother's name, the date of the client's birth, and the last two digits of the year of the client's birth. This code Clients either gave this information verbally when prompted or provided a wallet card with the code, which all clients received at their first visit. Volunteers or staff then also collected the following information at each visit:

- Number of returned needles
- Number of others for whom the client is picking up supplies
- Gender
- Race
- Neighborhood of residence
- Number of needles by type
- Sharps containers (check for yes)
- Other supplies (check for yes)
- Risk reduction education provided (check for yes)
- Referrals: testing, case management, overdose prevention, other (check for yes)
- Drug treatment referral (accepted or declined)
- Number of pieces of literature provided to client

Prevention Point data used for this project includes all New or Returning Exchanger forms from 2015. Data from clients who identified their neighborhood as somewhere outside of the city of Pittsburgh were removed from the project. Cases were also removed if missing data made the entry unusable; for example, if the client did not provide a neighborhood of residence. There were a total of 1,745 visits included out of the original 3,064; thus, this analysis represents 56.95% of the total needle exchange visits in 2015.

2.1.2 Allegheny County Health Department: HCV Cases (2015)

Allegheny County Health Department (ACHD) provided numbers of HCV cases investigated in 2015, grouped by neighborhood of the individual's residence. HCV is classified as a reportable disease by ACHD; HCV must be reported within five working days of diagnosis. 2015 was the first year ACHD investigated positive HCV cases that were reported; in total, healthcare providers reported 2,123 cases directly to ACHD in 2015. The data used in this project excludes cases ACHD was unable to investigate; cases in which the individual's residence was listed as a facility, such as a jail or rehabilitation; cases in which a residence was not provided because the individual was homeless; and cases where only a P.O. box address was provided. 1,855 cases remained after these eliminations from the county dataset, out of which 614 cases could be mapped to one of the 57 Pittsburgh neighborhoods selected for this research.

2.1.3 Pittsburgh Department of City Planning: SNAP Raw Data (2010)

The data used in this research to indicate social disorganization are drawn from a raw dataset published publicly online by Pittsburgh's Department of City Planning at http://www.pittsburghpa.gov/dcp/snap/raw_data. This dataset draws from many sources, including the 2010 census, and provides information on all 90 neighborhoods within the city boundaries. Neighborhood variables from the dataset used for this project include: percent African American, percent renter-occupied, median home value, percent less than high school education, percent under poverty line, and percent of housing in poor or derelict condition.

Information concerning neighborhoods other than those selected for this project was excluded. The dataset is available online on the City of Pittsburgh website.

2.1.4 Western Pennsylvania Regional Data Center: Pittsburgh Neighborhood Boundaries (2017)

The neighborhood boundaries for this project were generated from a publicly-accessible Shapefile on the Western Pennsylvania Regional Data Center (WPRDC) website. This boundary map originates from the City of Pittsburgh and is available at www.wprdc.org. The boundaries were adapted for this project to include only the neighborhoods selected for this research.

2.2 VARIABLES

The following variables were used in the analysis and were generated directly or indirectly from the data sources above:

- HCV Cases Per 100,000 population

  Count of cases in each neighborhood (ACHD, 2015) divided by the neighborhood population (Department of City Planning, 2010), multiplied by 100,000.

- NEP Utilization (Needles Distributed Per Population)

  Total needles distributed by Prevention Point Pittsburgh in 2015 to residents of each neighborhood (PPP, 2015) divided by the population of each neighborhood.

- Social Disorganization Indicators

These variables were selected on the basis of previous use in the literature and availability. All of the variables were available in the Pittsburgh Department of City Planning SNAP dataset (2010).

- Percent African American: percentage of the total neighborhood population that identifies as African American.
- Median home value: median value of houses in each neighborhood
- Percent of buildings in poor or derelict condition: percentage of all buildings in the neighborhood rated as "poor or derelict condition."
- Percent renter occupied housing: percentage of all neighborhood residential housing that is occupied by renters rather than homeowners. This variable serves to measure mobility of the population.
- Percent less than high school education: percentage of the neighborhood population that has not completed a high-school-level education. This serves as a measure of socioeconomic status.
- Percent in poverty: percentage of the neighborhood population that has an income below the poverty threshold. This serves as a measure of socioeconomic status.

- Neighborhoods

The boundary map for all neighborhoods within the city was available through the Western Pennsylvania Regional Data Center (2017). In total, the boundaries identify 90 distinct neighborhoods and one borough.

This analysis excluded Mt. Oliver Borough and the neighborhood of the same name, as the two are indistinguishable in the Prevention Point dataset. In addition, 39 neighborhoods were combined into seven different regions that represent the manner in which Prevention

Point exchangers (and most Pittsburgh residents) self-identify their neighborhoods of residence. The seven regions included Squirrel Hill (two neighborhoods), Northside (18 neighborhoods), Southside (three neighborhoods), Oakland (four neighborhoods), the Hill District (six neighborhoods), Homewood (three neighborhoods), and Lawrenceville (three neighborhoods). The average values or overall rates of the combined neighborhoods were calculated for the variables in the seven regions. With these exclusions and combinations, 57 total "neighborhoods" were included.

2.3 ANALYSES

2.3.1 Hypotheses

This research project included statistical tests of the following two hypotheses, as well as an exploratory analysis and mapping using Geographic Information Systems software:

H_1: There is a statistically significant difference in neighborhood-level HCV rates based on neighborhood-level population indicators of social disorganization.

H_2: There is a statistically significant difference in the relationship between neighborhood-level Median Home Value and HCV rates based on neighborhood-level needle exchange utilization. The relationship between Median Home Value and HCV rates is weaker in neighborhoods with higher needle exchange utilization compared to neighborhoods with lower needle exchange utilization.

2.3.2 Exploratory Analysis

An exploratory analysis was conducted to provide information that might inform public health efforts and needle exchange activities. The exploratory analysis primarily focused on describing the characteristics of needle exchange visitors. SPSS Statistics version 24 was used to generate descriptive information about the variables used in the analysis. QGIS version 2.14.3 was used to generate maps of neighborhood HCV rates, needle distribution, and needle exchange sites.

2.3.3 Linear Regression to Test Hypothesis 1

A linear regression was conducted in SPSS to calculate associations between the HCV rate and neighborhood-level population social disorganization indicators. Four predictor variables, Percent African American, Percent Poverty, Percent of Poor or Derelict Buildings, and Median Home Value, were used to test the first hypothesis. Preliminary bivariate Pearson correlations were conducted with each of the predictor variables and the dependent variable. Then each predictor variable was centered using the mean. All independent variables were tested for correlation with the dependent variable. The variables were as follows:

- Dependent variable: HCV rate per 100,000
- Independent variables:
    - Percent African American
    - Percent Poverty
    - Percent Buildings in Poor or Derelict Condition
    - Median Home Value
    - Percent Renter Occupied

- Percent Less than High School Education

2.3.4 Linear Regression to Test Hypothesis 2

A second linear regression was conducted in SPSS to predict HCV rate per 100,000 based on neighborhood-level population social disorganization indicators and needle exchange utilization. This regression was conducted to test whether the relationship between median home value and HCV rates is weaker in neighborhoods with higher NEP utilization. The variable chosen as a predictor for this regression to represent social disorganization was the one that most significantly predicted HCV rate in the regression equation to test hypothesis 1, "Median Home Value."

Two models were run. The first included the centered independent variables "Median Home Value" and "NEP Utilization." The second model included the previous two variables as well as an interaction term, which combined "Median Home Value," and "NEP Utilization" to evaluate the moderating effect of "NEP Utilization."

3.0 RESULTS

3.1 EXPLORATORY ANALYSIS

Characteristics of Prevention Point's visitors represented the primary focus of the exploratory analysis. In 2015, Prevention Point Pittsburgh distributed 158,122 needles to exchangers who identified as residents of the 57 selected neighborhoods (total neighborhood general population= 299,902). There were a total of 1,725 exchanger visits to Prevention Point's distribution sites; the data suggests that there were 1,708 individual exchangers. Based on the Lansky et al. estimate that .30% of the population has injected drugs in the past year, Prevention Point distributed approximately 136.55 needles per Injection Drug User in 2015 among the selected neighborhoods. The frequency of visitors over the course of the year is described in Figure 1 Tables 1 and 2 provide descriptive information regarding each the neighborhoods included in the analysis.

Individuals who identified as African American made 32.3% of the visits to the exchange sites, while individuals identifying as white made 67.0% of the visits in 2015. Males made up 70.8% of the visits, females 27.1%, and transgender individuals 1.7%. A chi-square test of independence was calculated comparing frequency of needle exchange between racial and gender groupings. A significant interaction was found (χ^2 (8) = 125.008, $p<.0001$). African

American men and white women made more of the visits to the exchange than expected. Fewer African American women and fewer white men visited the exchange than expected.

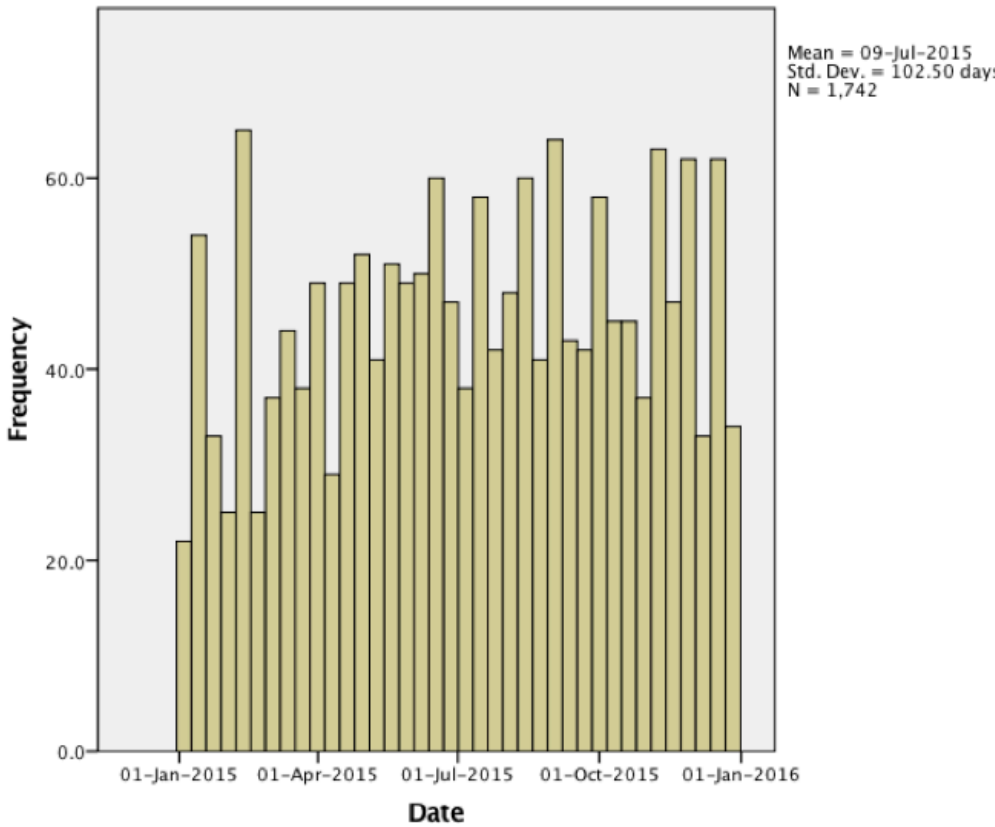

Figure 1. Frequency of visitors.

The age of visitors to the exchange ranged from 21 years old to 84 years old. The average age of visitors in 2015 to Prevention Point was 48.01, with a standard deviation of 13.56 (Figure 2, Age distribution of visitors). An independent-samples t-test was conducted to compare age in visitors whose race was identified as African American versus white. The test found statistically significant differences in age between African American (M=59.28, SD=9.140) and white (M=42.64, SD=11.887) needle exchange visitors in 2015; t(1729) = 29.306, p<.0001. The average age of the African American visitors was significantly higher than the average age of the white visitors.

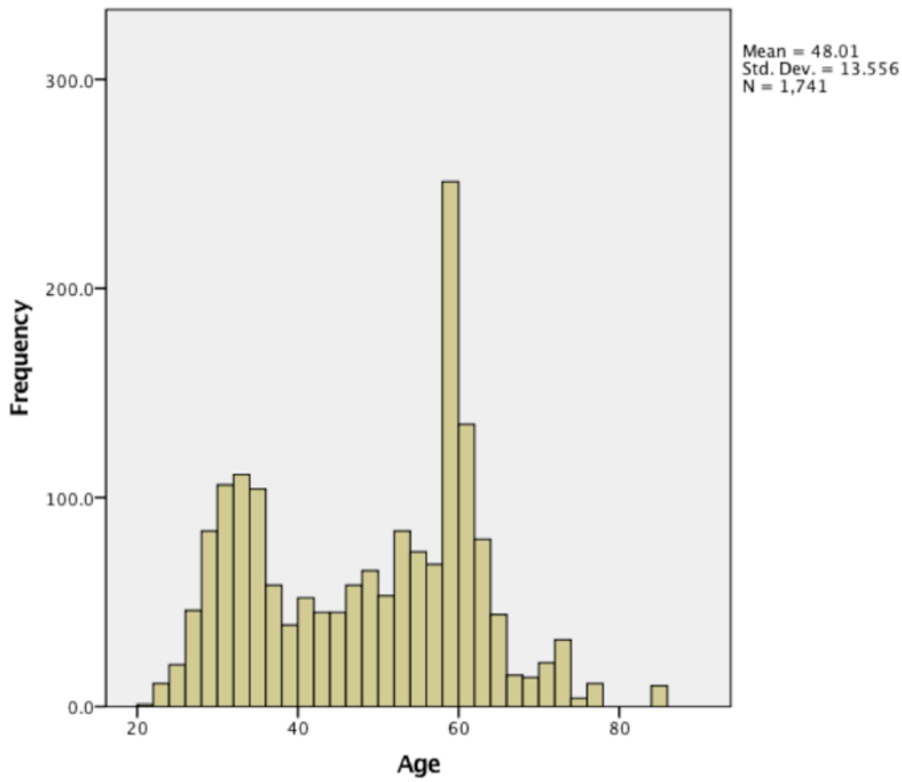

Figure 2. Age distribution of visitors

HCV and utilization of needle exchange services varied greatly among the different neighborhoods. HCV rates (cases per 100,000 people) were highest in Allentown (560.00), Knoxville (507.07), St. Clair (478.47), East Liberty (477.00), and Hazelwood (440.12). Excluding neighborhoods with no reported cases in 2015, HCV rates were lowest in Squirrel Hill (56.66), Oakland (67.54), Shadyside (71.86), Banksville (72.39), and Windgap (73.05). Needle exchange utilization (total needles per population) was highest in West End (3.66), the Hill District (2.89), Arlington (1.15), Bloomfield (1.14), and Hazelwood (1.09). A map of HCV cases per 100,000 people in each neighborhood is depicted in Figure 3 and a map of needle exchange utilization is depicted in Figure 4.

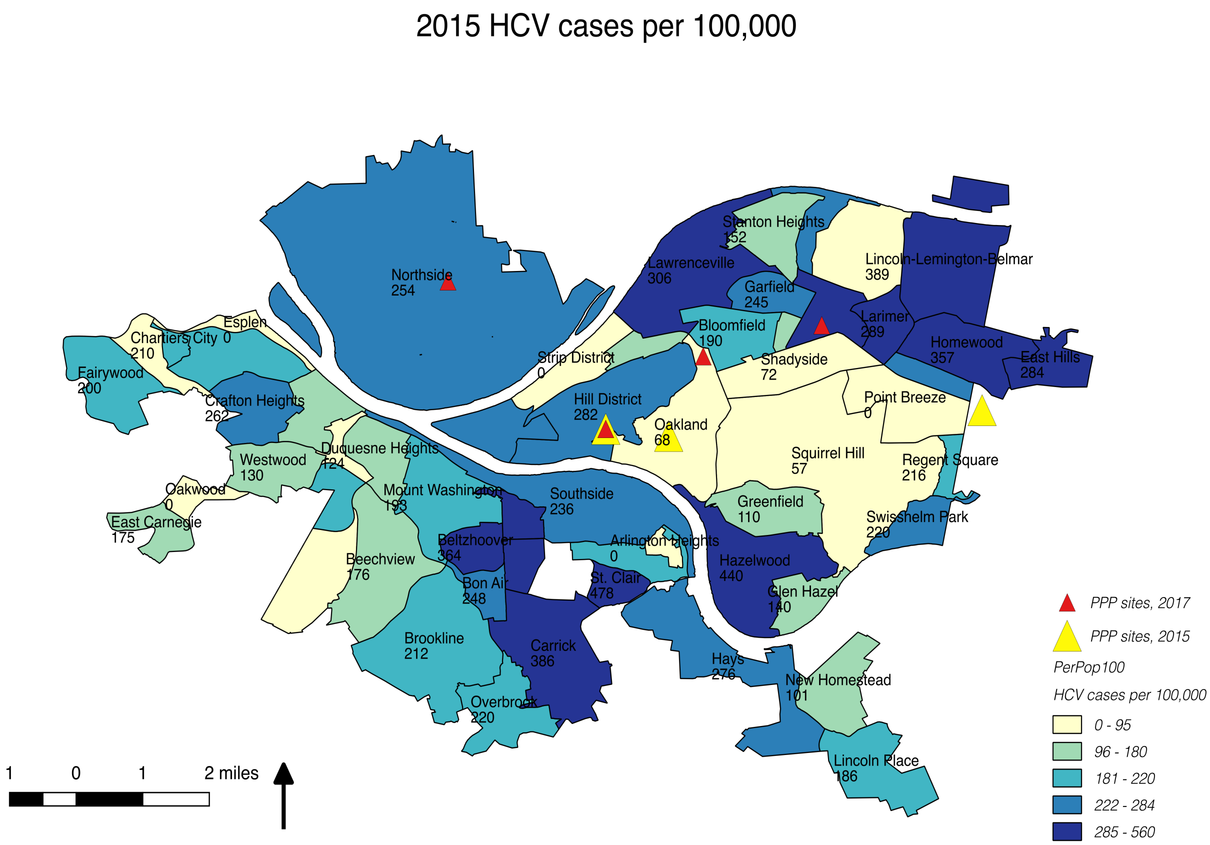

Figure 3. 2015 HCV cases per 100,000

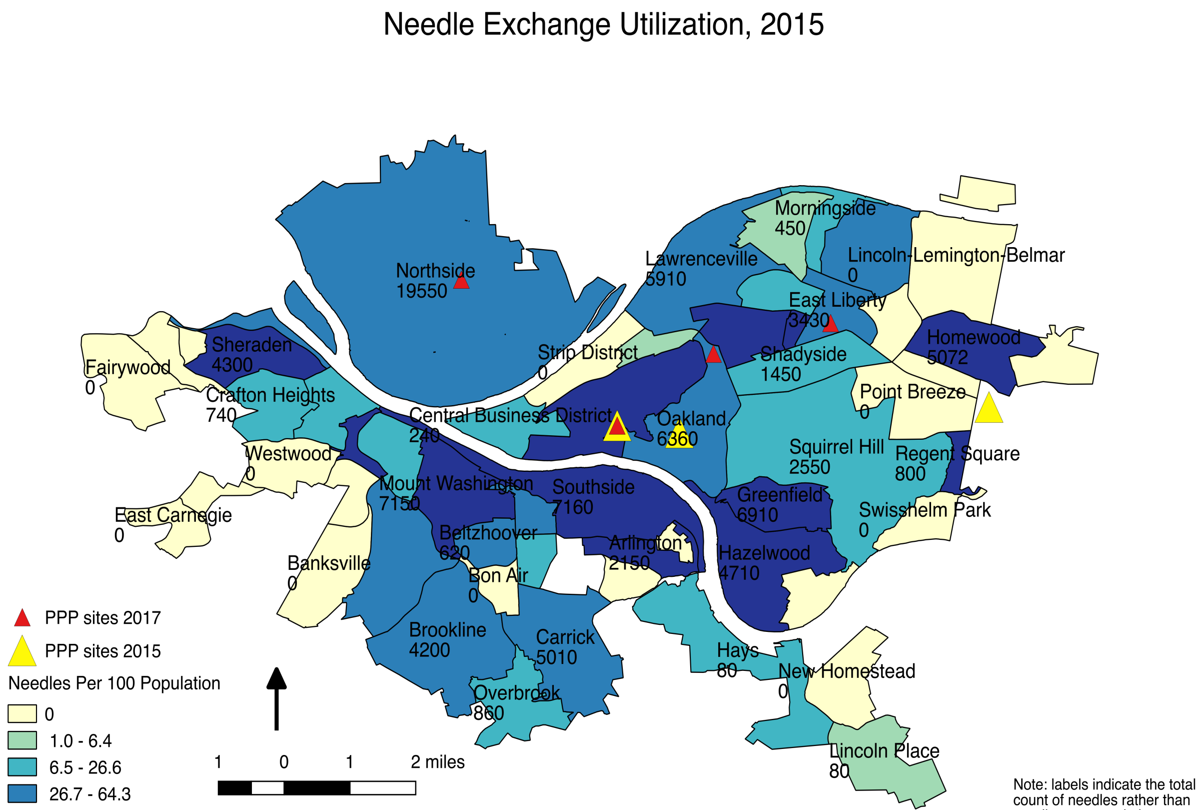

Figure 4. 2015 Needle Exchange Utilization

Table 1. Neighborhood characteristics

	Minimum	Maximum	Mean	Standard Deviation
Population	209	35,460	5,261.44	6,713.01
Total needles	0	49,210	2,774.07	7,112.93
HCV rate per 100,000	0	560.00	206.61	133.39
Percent African American	1.49	94.53	30.288	28.29
Median Home Value	26,800	215,900	67,332.55	38,274.43
NEP Utilization (needles per population)	0	3.66	.38	.66

Table 2. Variables used for regression

Variable	Mean	Correlation with HCV Rate	p-value
Percent African American	30.288	r=.384	.003
Percent Poverty	20.721	r=.277	.037
Percent Buildings Poor/Derelict	4.065	r=.504	.020
NEP Utilization	.385	.013	.921
Median Home Value	67,332.550	r=.504	<.0001
Percent Less than High School education	13.853	.299	.024
Percent Renter-Occupied	41.795	.034	.801
HCV rate per 100,000	206.611	---	---
Interaction term, Median Home Value*NEP Utilization	19,211.096	-.186	.169

3.2 REGRESSION ANALYSIS

3.2.1 Regression analysis to test H_1

A linear regression was calculated to test the hypothesis that HCV rates vary among neighborhoods based on indicators of social disorganization. The Pearson correlations, significance, and means of each variable used in the regression are described in Table 1. “Percent Renter-Occupied,” which was originally proposed as an independent variable, was excluded from the regression because there was no linear correlation with the dependent variable (mean=41.795, r=.069, p=.314). "Percent Less than High School Education" was also excluded from the regression because it was highly redundant with the other predictors (mean=13.854, r=.299, p=.024).

A significant regression equation was found ($F(4,48)=7.176$, $p<.0001$), with an R^2 of .374. The predicted HCV rate per 100,000 of each neighborhood is equal to 211.551 + 1.320 (Percent African American) + .269 (Percent Poverty) + .919 (Percent Buildings Poor/Derelict) - .001 (Median Home Value). Median Home Value was a significant predictor at $p<.01$. Table 3 describes the regression results. Figure 5 depicts the correlation scatter plot of HCV rate and Median Home Value, which was the most significant predictor in the regression equation. The results of this regression provide support to reject the null hypothesis, that there is no significant change in neighborhood-level HCV rates based on change in neighborhood-level indicators of social disorganization.

Table 3. H_1 regression results

Coefficients[a]								
Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	(Constant)	252.583	47.733		5.292	.000	---	---
	Percent of population African American	1.320	.756	.282	1.747	.087	.499	2.003
	Percent of population under poverty line	.269	1.393	.029	.193	.848	.592	1.689
	Percent of buildings in poor or derelict condition	.919	4.159	.035	.221	.826	.522	1.916
	Median Home Value	-.001	.000	-.403	-3.106	.003	.773	1.293
a. Dependent Variable: HCV rate per 100000								

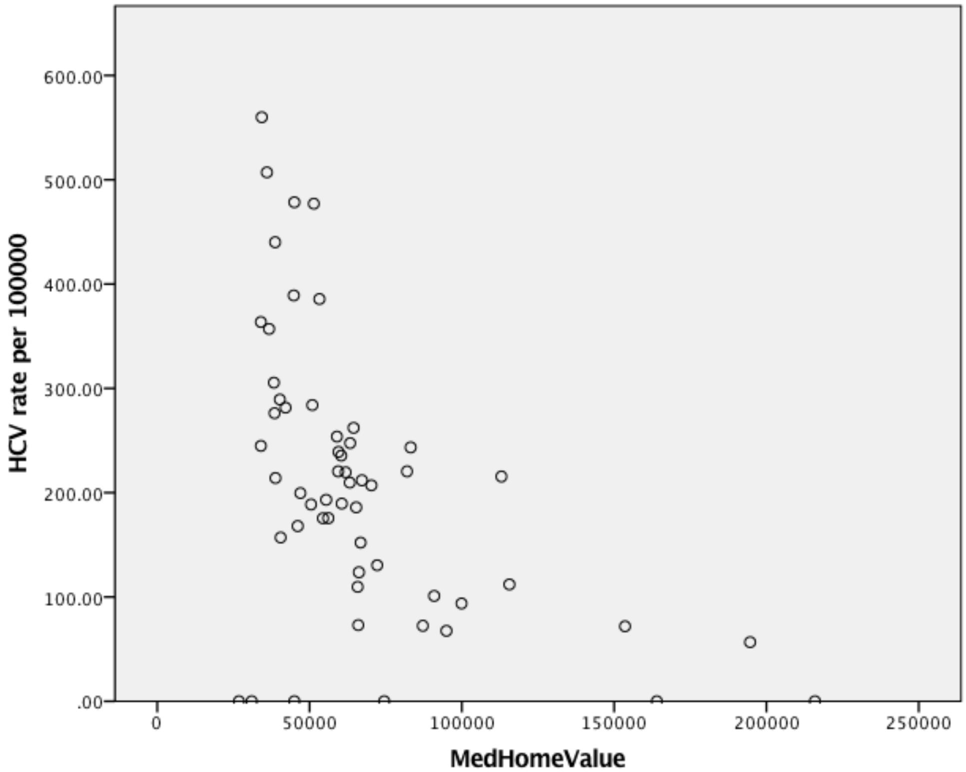

Figure 5. Median home value and HCV cases per 100,000 scatterplot

3.2.2 Regression analysis to test H_2

A linear regression was calculated to test the hypothesis that the relationship between Median Home Value and HCV rates is weaker in neighborhoods with higher NEP utilization. The Pearson correlations, significance, and means of each variable used in the regressions are described in Table 1. The independent variables chosen were "NEP Utilization" and "Median Home Value," which had the strongest predictive value according to the regression analysis to test H_1. All the predictor variables were centered before conducting the regression. An interaction term was created that combined Median Home Value and NEP Utilization, as measured by needles distributed divided by the population.

A significant regression equation was found ($F(3,52)=7.231$, $p<.0001$), with an R^2 of .294. Median Home Value was significant ($p=.007$), however, the interaction term was not significant ($p=.174$). This regression provides no evidence that the relationship between Median Home Value and HCV rates is weaker in neighborhoods with higher NEP utilization. There is evidence, however, that neighborhoods with higher median home values have lower HCV rates. Results of the regression are shown in Table 4.

Table 4. H_2 regression results

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	207.980	15.635		13.302	.000
	Median Home Value	-.002	.000	-.535	-4.411	.000
	NEP Utilization	-25.474	24.684	-.125	-1.032	.307
2	(Constant)	217.829	17.069		12.762	.000
	Median Home Value	-.001	.001	-.415	-2.794	.007
	NEP Utilization	21.211	41.773	.104	.508	.614
	Interaction Term (NEP * Median Home Value)	.002	.001	.281	1.379	.174

a. Dependent Variable: HCV rate per 100000

4.0 DISCUSSION

4.1 FINDINGS

These results contribute to the collection of literature that uses social disorganization theory to predict health outcomes. This is the first study to examine social disorganization indicators related to HCV rates in Pittsburgh neighborhoods, and the first study to map needle exchange utilization in Pittsburgh by neighborhood. The results of this research provide preliminary evidence that HCV rates at the neighborhood level change based on indicators of social disorganization. Specifically, the racial makeup of neighborhoods was a weak predictor and Median Home Value was a statistically significant predictor of HCV incidence rates using 2015 data. Though they were not significant predictors in the regression analysis, poverty, building conditions, and education level showed statistically significant correlations with HCV incidence rates at the neighborhood level (p=.037, .020, .024). The exploratory analysis provides evidence that needle exchange utilization varies based on race and gender. However, there is no evidence to suggest that needle exchange utilization moderates the relationship between social disorganization predictors and HCV rates, or that needle exchange utilization itself is related to HCV rates in any way.

4.2 LIMITATIONS

This study was limited by its data sources, design, and sample size. First, this study used visits as individual cases in the needle exchanger database. This was necessary due to errors in the process of exchangers reporting and volunteers documenting identifying codes. Thus, an accurate number of individual exchangers in 2015 could not be generated; this number may have served as a more appropriate measure for this study than number of needles per neighborhood population. Future research could match individual cases based on a combination of characteristics and attempt to estimate number of individuals.

The needle exchange data were also limited by the manner in which exchangers identify their neighborhoods. Individuals who live in one of many Northside neighborhoods, for example, typically identify as residents of the "Northside" only, which actually consists of 18 formal neighborhood areas. Thus, the exploratory analysis and regressions were missing a level of detail in such regions; variables in individual neighborhoods and those in the merged regions may not be entirely comparable.

Both the needle exchange data and HCV rates data provide only a cross-section of information over a single year period. The resulting sample size may not have had enough power to demonstrate a moderating effect of needle exchange. Even if a moderating effect could have been demonstrated, there would have been no potential to demonstrate a causative relationship. Considering these factors and the continuously changing nature of the opioid epidemic, a larger timeframe with greater numbers of cases would be ideal in future studies.

This type of design is also subject to ecological fallacy. Any relationships demonstrated between the study variables at the population level do not imply that these relationships exist at the individual level. Future research could gather individual-level information and examine the influence of community characteristics on individual needle-exchange utilization and HCV infection.

4.3 FUTURE DIRECTIONS

Future research regarding social disorganization theory and HCV in Pittsburgh could begin by incorporating a larger sample into a similar design to examine the significance and impact of needle exchange. In addition, research could identify other social disorganization indicators and their ability to predict HCV rates. Identifying neighborhood factors that predict needle exchange utilization may be a valuable direction for future research, and may help point out access disparities.

Research that could be particularly valuable to Prevention Point's activities might include additional mapping of the spatial distribution of exchangers over time. This would also allow Prevention Point to examine the reach of their services and to determine whether there is a spatial relationship between site locations and service utilization. This could help identify access disparities and suggest locations for future sites.

Future research could also examine the neighborhood residence of individual exchangers who utilize HCV testing services at Prevention Point. Similar to many previous social disorganization theory studies, this research could suggest whether the odds of testing positive are related to neighborhood characteristics. This type of research might be more suggestive of the impact of the environment on individual behavior.

4.4 CONCLUSION

This research provides some preliminary evidence of a relationship between social disorganization indicators and HCV rates at the neighborhood level in Pittsburgh. The results provide no evidence that needle exchange utilization at the neighborhood level relates to HCV rates. However, the study was significantly limited by the data sources. As injection drug use and HCV rates are increasing over time, population-level predictors are valuable public health tools. Demonstrating the value of needle exchange at the population level could provide support for these interventions in the policy-making arena. While this study did not demonstrate a moderating effect of needle exchange, this study could serve as a template for future research that could demonstrate the value of needle exchange using different indicators and datasets spanning a longer time period. Future research should incorporate a span of time greater than one year for HCV incidence and NEP utilization, which would provide more power to detect statistical relationships.

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