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Examining the Effects of Neighborhood Factors and Geography on Racial/Ethnic Disparities in Achieving Sustained Viral Suppression

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EXAMINING THE EFFECTS OF NEIGHBORHOOD FACTORS AND GEOGRAPHY ON RACIAL/ETHNIC DISPARITIES IN ACHIEVING SUSTAINED VIRAL SUPPRESSION

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To: Dean Tomás R. Guilarte
Robert Stempel College of Public Health and Social Work

This dissertation, written by Rahel Dawit, and entitled Examining the Effects of Neighborhood Factors and Geography on Racial/Ethnic Disparities in Achieving Sustained Viral Suppression having been approved in respect to style and intellectual content, is referred to you for judgment.

We have read this dissertation and recommend that it be approved.

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The dissertation of Rahel Dawit is approved.

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DEDICATION

This dissertation is dedicated to my parents Dawit Gebremedhin and Alemtsehay Getanhen, and to my younger brother, Yonatan Dawit.

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ABSTRACT OF THE DISSERTATION

EXAMINING THE EFFECTS OF NEIGHBORHOOD FACTORS AND GEOGRAPHY ON RACIAL/ETHNIC DISPARITIES IN ACHIEVING SUSTAINED VIRAL SUPPRESSION

by

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Sustained viral suppression (all viral load tests <200 copies/mL in a year) decreases the risk of HIV transmission and disease progression to AIDS for people with HIV. Racial/ethnic minorities living with HIV are particularly challenged by barriers, including neighborhood factors, to maintain viral suppression. This dissertation examined the contribution of neighborhood and geographic factors on racial/ethnic disparities in achieving sustained viral suppression. A cross-sectional analysis of secondary data collected in 2017 for 6491 clients enrolled in the Miami-Dade County Ryan White Program (RWP) was conducted.

The first study examined the moderating role of neighborhood level factors on the association between race/ethnicity and sustained viral suppression for 6491 RWP clients. Using multilevel logistic regression models, we observed that non-Hispanic Blacks (NHB) had lower odds of sustained viral suppression compared to non-Hispanic Whites (NHW) in low socioeconomic disadvantage (adjusted odds ratio [aOR]: 0.39; 95% confidence interval [CI]: 0.20-0.74), moderate residential instability (aOR: 0.31; CI: 0.15-0.65), and low (aOR: 0.38; CI: 0.16-0.88) and high (aOR: 0.38; CI: 0.19-0.75) racial/language homogeneity neighborhoods. Moreover, Haitians also had poor sustained viral suppression in moderate residential instability (aOR: 0.42; CI: 0.18-0.97)

and high racial/language homogeneity (aOR: 0.49; CI: 0.26-0.93) neighborhoods, when compared to NHW.

The second study examined individual and neighborhood level factors that are associated with residing in geographic hotspots of poor sustained viral suppression. Using spatial autocorrelation tools, we identified 10 hotspots of poor sustained viral suppression. Using multivariable logistic regression models, we identified race/ethnicity, age, poverty, and neighborhood-level characteristics were significantly associated with residing in hotspots of poor sustained viral suppression.

The third study examined the moderating effect of travel distance and transportation needs to Medical Case Management (MCM) sites and AIDS Drug Assistance Program (ADAP) pharmacies on the association between race/ethnicity and sustained viral suppression. We observed that racial/ethnic minorities had poor sustained viral suppression compared to NHW among clients without access to transportation and other travel distance related variables (travel distance to the nearest facility of care, median travel distances to clients MCM site of choice, and median travel distance to nearest ADAP pharmacy).

In conclusion, racial/ethnic difference in achieving sustained viral suppression were observed within different neighborhood characteristics and geographic locations across Miami-Dade County. Sustained viral suppression supports the “(U=U) Undetectable=Untransmittable” concept that emphasizes the importance of consistent viral suppression to help end the HIV epidemic. Targeted place-based interventions within specific geographic locations and among racial/ethnic minorities should be implemented within Miami-Dade County to minimize the observed disparities.

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ABBREVIATIONS AND ACRONYMS

HIV	Human Immunodeficiency Virus
AIDS	Acquired Immunodeficiency Syndrome
PWH	People with HIV
ART	Antiretroviral Therapy
CD4	Cluster of Differentiation 4
GIS	Geographic Information System
RWP	Ryan White HIV/AIDS Program
ADAP	AIDS Drug Assistance Program
ACA	Affordable Care Act
NHB	Non-Hispanic Black
NHW	Non-Hispanic White
MSM	Men who have sex with men
IDU	Injection Drug Use
SES	Socioeconomic Status
MCM	Medical Case Management
FPL	Federal Poverty Level
ZIP	Zone Improvement Plan
ZCTA	ZIP Code Tabulation Areas
LISA	Local Indicator of Spatial Autocorrelation
aOR	Adjusted Odds Ratio
CI	Confidence Interval
US	United States

INTRODUCTION

HIV epidemiology and care outcomes

The human immunodeficiency virus (HIV) is a retrovirus that attacks and suppresses the immune system of an individual (Centers for Disease Control and Prevention 2021a). In the United States (US), there are currently 1.2 million people ≥13 years of age living with HIV; of these about 13.3% are people living with undiagnosed HIV (Department of Health and Human Services 2019b). In the most recent data (2019), there were 36,801 with diagnosed HIV and 15,815 deaths reported in the US (Department of Health and Human Services 2019b). Forty-six percent of people with HIV (PWH), 53% of new infections, and an estimated 50% of undiagnosed infections occur in southern region of the US (Department of Health and Human Services 2021). Moreover, the largest percentage of PWH in the US are racial/ethnic and sexual minorities, Blacks/African Americans and men who have sex with men (MSM) (Centers for Disease Control and Prevention 2019c).

Due to the advent of antiretroviral therapy (ART), PWH can better manage their HIV and improve their life expectancy. To assess progress towards HIV treatment goals, the HIV care continuum was conceptualized as a series of steps that a person takes for HIV medical treatment (Department of Health and Human Services 2019a). The care continuum includes being diagnosed with HIV, getting linked to care in a timely manner, being consistently engaged/retained in care, initiating and adhering to antiretroviral therapy medications, and ultimately achieving viral suppression (i.e. having a very low or undetectable vial load) (Department of Health and Human Services 2019a). Studies have shown that timely linkage to care and retention in care are associated with higher rates of viral suppression (Hall et al. 2013; Bradley et al. 2016a; Crepaz et al. 2018a), and that PWH who have achieved viral suppression decrease their risk of HIV

transmission to others and decreases their risk of disease advancement to acquired immunodeficiency syndrome (AIDS), the latent stage of the infection (Bradley et al. 2016a; Terzian et al. 2012; Bradley et al. 2014). One of the goals of the National HIV/AIDS strategy, which was implemented in 2010, is to improve the health outcomes of PWH in the US and ensure that 95% of PWH achieve viral suppression by 2025 (Department of Health and Human Services 2021). However, the US is far from reaching this goal. In 2019, only 56.8% of people with diagnosed HIV achieved viral suppression (Department of Health and Human Services 2019b).

Sustained HIV viral suppression

Most studies categorize people as being virally suppressed based on their most recent viral load. However, that measures viral load at a single point or snapshot in time and does not provide information about continuous suppression throughout a year (Crawford and Thornton 2017b). In order to ensure that viral load is consistently suppressed or maintained over time, some recent studies have examined sustained or durable viral suppression (Bradley et al. 2016a; Crawford and Thornton 2017b; Crepaz et al. 2018a; Crepaz et al. 2017a, 2017b; Crepaz et al. 2016; Marks et al. 2016b; Westergaard et al. 2013). Sustained viral suppression is defined as having a consistent viral load count of <200 copies/ml in all viral load lab tests within a 12-month period (Crepaz et al. 2016). In order to have a stronger indicator of changes in viral load over time, researchers should examine sustained viral suppression (Marks et al. 2015; Mugavero et al. 2011; Terzian et al. 2012). A recent study found that the use of a single measurement of viral load overestimates the percent of PWH with sustained viral suppression by 16% (Marks et al. 2016b). Another study that was conducted among 17 states has shown that PWH had a viral load of >200 copies/ml more than half of a two-year period (Crepaz et al. 2016). Furthermore, measuring sustained viral suppression

will ultimately strengthen the value of HIV treatment as a key prevention tool in the Undetectable=Untransmittable (U=U) concept which states that undetectable viral load does not transmit HIV to others (Fauci et al. 2019). Hence, it's necessary to examine factors that are associated with sustained viral suppression since consistent viral suppression ensures that disease transmission to others is minimized.

Racial/ethnic disparities in HIV care outcomes

Disparities in HIV care outcomes exist for racial/ethnic minorities who face inequalities in HIV care engagement, retention in care, and viral suppression (Doshi et al. 2017; Philbin et al. 2018). In 2018, among people living with diagnosed and undiagnosed HIV, 62.9% of African Americans had achieved viral suppression within the first 6 months of diagnosis, compared to 68.3% of Whites (Centers for Disease Control and Prevention 2018b). In a study conducted in 2014 of 38 jurisdiction in the US, African Americans have a lower rate of sustained viral suppression (40.8%) (Crepaz et al. 2018a) despite an increase in antiretroviral therapy (ART) prescription and viral suppression over time, when compared to Hispanics and Whites (Bradley et al. 2016a; Crepaz et al. 2017b; Beer, Bradley, et al. 2016b). These treatment-related disparities are attributed to numerous barriers that influence health outcomes for marginalized populations (Feller and Agins 2017). Socioeconomic factors such as poverty, unemployment and lack of educational attainment (Weiser et al. 2015; Beer, Mattson, et al. 2016), as well as lack of access to health care and health insurance, low health literacy, stigma, poor quality of provider-patient relationship, and lack of trust in the healthcare system are known factors that account for disparities in HIV care and treatment outcomes observed among racial/ethnic minorities (Crepaz et al. 2018a; Earl et al. 2013; McFall et al. 2013; Osborn et al. 2007). Additionally, lack of transportation, food insecurity, unstable housing, substance use, and depression are common barriers

to viral load suppression (Feller and Agins 2017). Furthermore, studies also suggest that the risk of secondary HIV transmission is higher for minorities due to high prevalence of the disease and the low rates of viral suppression in these groups (Crepaz et al. 2018a). Identifying factors that are associated with sustained viral suppression disparities among racial/ethnic minorities is essential to developing successful tailored interventions to improve health equity.

Neighborhood and geographic factors influence on HIV care outcomes

In addition to individual and healthcare system factors, neighborhoods and the built environment also influence HIV health outcomes. According to Healthy People 2020, neighborhood level determinants of health include access to food, exposure to crime and violence, environmental conditions and quality of housing (Healthy People 2020 2019). These factors play a role in a person's risk of acquiring disease, morbidity, mortality and their overall quality of life (Healthy People 2020 2019). Diez et al. states that racial/ethnic and socioeconomic segregation as well as disparities in resource allocation influence a neighborhood's physical (built environment, housing, environmental exposure, etc.) and social (safety, social cohesion, norms, networks etc.) environments (Diez Roux and Mair 2010b). Adverse neighborhood socioeconomic factors such as poverty, unemployment, and residential segregation have been associated with poor HIV care management (Rebeiro et al. 2018; Shacham et al. 2013). In addition, individuals residing in areas of high poverty and low educational attainment have exhibited lower CD4 cells counts (Shacham et al. 2013; Burke-Miller et al. 2016) and are less likely to be adherent to HIV medications (Shacham et al. 2013). Furthermore, some studies have identified geographic hotspots of poor linkage to care and poor viral suppression (Das et al. 2018; Goswami et al. 2016), and these areas have been associated with poor sociodemographic characteristics of income, poverty,

housing instability, inadequate transportation needs and crime (Eberhart et al. 2013b; Ransome et al. 2017b; Rebeiro et al. 2016).

However, findings regarding the effects of neighborhood predictors on HIV health outcomes have been mixed. Some studies have shown that higher poverty (Eberhart et al. 2015a) and residential segregation are associated with a lower probability of viral suppression. Residents of economically deprived neighborhoods are also less likely to maintain viral suppression when compared to those in more affluent neighborhoods (Wiewel et al. 2017a). Other studies have not found an association between neighborhood-level socioeconomic factors and viral suppression (Burke-Miller et al. 2016; Shacham et al. 2013; Sheehan et al. 2017b). Studies have examined varied measurements of neighborhood factors, including different neighborhood characteristics and definitions of neighborhoods, which could explain the disparate findings. Moreover, decreased accessibility to HIV care centers and longer travel distance to care facilities may also contribute to disparities in HIV health outcomes (Kimmel et al. 2018). The effects of these structural barriers differ by race/ethnicity, such that racial/ethnic minorities are disproportionally affected (Kimmel et al. 2018). Having reliable access to transportation also influences HIV care outcomes and is essential to ensure that PWH seek and are engaged in continuous care (Goswami et al. 2016; Kimmel et al. 2018). Furthermore, transportation access disparities, including lack of vehicle ownership and longer wait times for public transportations are mostly observed in economically deprived areas, and these disparities also serve as a barrier to optimal HIV care outcomes (Eberhart et al. 2015a; Goswami et al. 2016).

Regional differences in disparities in HIV care outcomes are also observed in the US. Southern states lag behind in offering adequate HIV care services (Centers for Disease Control and Prevention 2019b), and have exhibited poor HIV care and

treatment outcomes (Rebeiro et al. 2018), compared with other regions in the US. In 2017, four of the five states with highest HIV diagnosis rates and almost all (9 out of 10) of the metropolitan statistical areas (MSA) with the highest HIV rates were located in the southern region of the US (Centers for Disease Control and Prevention 2017). Miami-Dade County is one of the MSA with the highest HIV diagnosis rate in the US (Centers for Disease Control and Prevention 2017). In 2019, there were approximately 26,000 PWH in Miami-Dade County; of these 59% achieved viral suppression (AIDS Vu 2019). Studies have also shown a difference in rates of HIV care outcomes by gender, sexual orientation, and racial/ethnic groups (Sheehan et al. 2020; Trepka et al. 2020a).

Research Objective

Even though several studies have examined neighborhood and geographic factors that affect HIV viral suppression at a single point in time, to our knowledge there has been no study that has examined the effects of these factors on sustained viral suppression among vulnerable populations. Therefore, the objective of this dissertation is to assess the contribution of neighborhood and geographic factors to sustained viral suppression disparities among racial/ethnic minorities served by the Ryan White Program and residing in Miami-Dade County. The central hypothesis is that neighborhood disadvantage and distance to HIV care facility will contribute to racial/ethnic disparities in sustained viral suppression.

Study aims and hypothesis

Aim 1: In the first study we sought to identify the moderating role of neighborhood characteristics on the association between race/ethnicity and sustained viral suppression.

Hypothesis 1: Racial/ethnic minority disparities in sustained viral suppression would be larger in areas of higher neighborhood disadvantage.

Aim 2: In the second study, we identified individual and neighborhood level factors that are associated with residing in geographic hotspots of low sustained viral suppression.

Hypothesis 2: Residing in a geographic hotspot of poor sustained viral suppression would be associated with higher neighborhood-level disadvantage and higher concentration of racial/ethnic minorities.

Aim 3: In the third study, we examined the moderating effect of travel distance and transportation needs to Medical Case Management (MCM) sites and AIDS Drug Assistance Program (ADAP) pharmacies on the association between race/ethnicity and sustained viral suppression.

Hypothesis 3a: Longer travel distance to HIV MCM sites and ADAP pharmacies would be more strongly associated with lower rates of sustained viral suppression for racial/ethnic minorities compared to non-Hispanic Whites.

Hypothesis 3b: Lack of access to transportation to HIV MCM sites and ADAP pharmacies would be more strongly associated with lower rates of sustained viral suppression for racial/ethnic minorities compared to non-Hispanic Whites

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MANUSCRIPT 1

Neighborhood Factors Associated with Racial/Ethnic Disparities in Achieving Sustained HIV Viral Suppression among Miami-Dade County Ryan White Program clients

Abstract

Racial/ethnic minorities are disproportionately affected by poor HIV care outcomes. Studies have also examined the effects of neighborhood level factor on an individual's health outcomes. Thus, the objective of this study was to assess the effects of neighborhood factors on the association between race/ethnicity and sustained viral suppression (all viral load tests <200 copies/ml per year). Data for 6491 people with HIV in the 2017 Miami-Dade County Ryan White Program and neighborhood level data by ZIP code tabulated areas from the American Community Survey were utilized. Multilevel logistic regression models were used to assess the role of neighborhood factors on the association between race/ethnicity and sustained viral suppression. Results show that non-Hispanic Blacks had lower odds of sustained viral suppression in low socioeconomic disadvantage (adjusted odds ratio [aOR]: 0.39; 95% confidence interval [CI]: 0.20-0.74), moderate residential instability (aOR: 0.31; 95% CI: 0.15-0.65), and low and high racial/language homogeneity neighborhoods (aOR: 0.38; 95% CI: 0.16-0.88) and (aOR: 0.49; CI: 0.26-0.93), respectively, when compared to non-Hispanic Whites. Haitians also exhibited poor outcomes in neighborhoods characterized by moderate residential instability (aOR: 0.42; 95% CI: 0.18-0.97) and high racial/language homogeneity (aOR: 0.38; CI: 0.19-0.75), when compared to non-Hispanic Whites. In conclusion, disparities in rates of sustained viral suppression were observed for racial/ethnic minorities within various neighborhood level factors. These findings indicate

the importance of addressing neighborhood characteristics to achieve optimal care for minorities.

Introduction

Neighborhood level factors such as physical and social environments explain the endogenous and contextual determinants of health that can wield considerable influence on health outcomes (Diez Roux and Mair 2010a; Latkin et al. 2005; Surratt et al. 2015; Duncan and Kawachi 2018). A neighborhood's social environment can be described using theories such as social disorganization, neighborhood disadvantage, and disorder, which are largely intertwined. The three dimensions of social disorganization (concentrated disadvantage, residential instability, and ethnic heterogeneity) have been used to critically examine the role of neighborhoods on health behavior and crime (Browning and Cagney 2002b). Concentrated disadvantage is characterized by lack of adequate resources for basic needs, residential instability disturbs social networks and deteriorates community ties due to high mobility, and ethnic heterogeneity hinders shared commonalities and communications, which weakens social cohesion and collective efficacy (Browning and Cagney 2002b; Kowitt et al. 2018). The lack of preservation of social ties and economic resources in neighborhoods promotes social disorganization and disorder (Browning and Cagney 2002b; Marco et al. 2015; Ross and Mirowsky 2001). Moreover, neighborhoods with high degree of social and physical disorder create a hostile living environment that has deleterious effects on health (Kerr et al. 2015a; Latkin et al. 2005; Surratt et al. 2015) and contributes to racial/ethnic differences in life-expectancy (Cerdá et al. 2009). Furthermore, residential segregation is a major driver for racial and socioeconomic health disparities (Williams and Collins 2016; Duncan and Kawachi 2018). Residential segregation and inequalities in resource distribution affect a neighborhood's environment, which then influences an individual's

behavior and stress response, and coupled with psychosocial factors, ultimately affects health outcomes (Diez Roux and Mair 2010a). In particular, African Americans often reside in racially segregated, and economically and socially deprived neighborhoods with limited access to resources (Kerr et al. 2015a).

People with HIV (PWH) who have a suppressed viral load greatly reduce their risk of disease progression to AIDS and transmitting the disease to others (Crepaz et al. 2016; Jefferson et al. 2017). Once an individual is virally suppressed, it is imperative that viral suppression is sustained long term. Sustained viral suppression, defined as having all viral load tests within a year as <200 copies/ml, is critically important as breaks in viral suppression within a year might increase the possibility of transmitting HIV to others (Crepaz et al. 2016; Marks et al. 2016a). Studies have shown that disparities in sustained viral suppression exist by race/ethnicity (Crepaz et al. 2018b; Jefferson et al. 2017). Despite the increased use of antiretroviral medication over the years, African Americans have lower rates of sustained viral suppression than Hispanics and non-Hispanic Whites, and spend more than half of the year with viral loads >1,500 copies/ml (Beer, Bradley, et al. 2016a; Crepaz et al. 2018b). Elevated disease burden, health disparities, and inequities are, in part, attributed to neighborhood level factors (Surratt et al. 2015) including HIV health outcomes (Crockett et al. 2019). Poor HIV care outcomes including lack of medication adherence and unsuppressed viral load have been associated with neighborhoods characterized by economic deprivation and residential segregation (Wiewel et al. 2017b; Eberhart et al. 2015b; Rebeiro et al. 2018; Surratt et al. 2015). Increased neighborhood disorder has also been associated with poor HIV medication adherence, which is necessary to achieve and maintain viral suppression (Crockett et al. 2019; Surratt et al. 2015). However, little is known about the role of neighborhood factors on achievement of sustained viral suppression. Therefore, the

objective of this study was to examine the contribution of neighborhood level factors on sustained viral suppression and to assess how the effects of neighborhood context vary by race/ethnicity. This study hypothesizes that racial/ethnic minority disparities in sustained viral suppression will be larger in areas with poor neighborhood characteristics.

Methods

Datasets and study design

A cross-sectional study was conducted using 2017 client data from the Miami-Dade County, Ryan White Program (RWP) (Department of Health and Human Services 2017). The Miami-Dade RWP provides care to nearly 10,000 low-income uninsured or underinsured PWH every year. Clients in this study were adults ≥18 years of age, who had received medical case management services, medical care, and viral load lab test throughout 2017. Clients whose cases were closed (due to financial ineligibility, relocation, or mortality), those with missing client assessment or viral load data, missing residential ZIP codes, or who only received ancillary services from the RWP were excluded from this analysis.

Neighborhood-level data were collected from the American Community Survey (ACS) (Census Data 2017) and Simply Analytics (an online data visualization platform that pools demographic, economic, and health data from various data partners on various health measures) (Simply Analytics 2019). The 2013-2017, five-year estimates were obtained by ZIP code tabulated areas (ZCTA), which are geographic units used to approximate ZIP codes. Additionally, homicide index was collected by ZIP codes from Simply Analytics. A total of 75 Miami-Dade ZCTA's were used in this analysis. ZCTA's that were commercial zones were excluded from the analysis and one-to-one matching of ZIP codes to ZCTAs were conducted

Predictor variables: Individual level

Individual level client characteristics assessed as categorical variables include age, gender, US nativity, mode of HIV exposure, history of AIDS Diagnosis, recipient of RWP subsidized ACA health care, household income in federal poverty level (FPL), and HIV provider's RWP client load. A total of 16 vulnerable and enabling related variables were selected, based on the Andersen Behavioral Model for HIV Health Care Utilization (Christopoulos, Das, and Colfax 2011; Ulett et al. 2009b), and variables available in the RWP dataset, to create the indices for psychosocial variables using principal component analysis (Supplemental Table). Andersen's model assesses health care environment and vulnerable, enabling, and need factors to determine health service seeking behaviors. Principal component analysis with and without an orthogonal varimax rotation was used to select three indices, mental health index (components loadings: 0.57- 0.58), substance use index (components loadings: 0.48-0.55), and income/SES index (components loadings: 0.47-0.48). A continuous composite score for each index were also calculated.

Predictor variables: Neighborhood level variables

Neighborhood level variables were selected based on social disorganization theory, while homicide index was used to assess neighborhood disorder. Using similar methods as the individual-level psychosocial indices, neighborhood indices were developed for 24 variables that were collected from ACS and were used as a proxy for social characteristics in prior literature (Supplemental Table) (Diez Roux and Mair 2010a; Trepka et al. 2020b). This created three indices (socioeconomic [SES] disadvantage index, residential instability index, racial/language homogeneity index), that were categorized into tertiles (low, moderate, high). The SES disadvantage index (components loadings: 0.54-0.89) was composed of twelve variables including public

assistance, vehicle ownership, crowding, income disparity, education, occupation, and employment. The residential instability index consisted of rented housing and mobility (components loadings: 0.65-0.75). Finally, racial/language homogeneity index consisted of percent non-Hispanic Black and English language proficiency (components loadings: 0.75-0.78).

Outcome variable

Sustained viral suppression was the outcome of interest and was defined as having <200 copies/ml in all viral load laboratory tests during 2017 (Crepaz et al. 2018b). Clients were required to have more than one viral load test within a year and those with any unsuppressed viral load test were not considered sustained. If an individual had only one suppressed viral load test or had multiple suppressed viral load tests <3 months apart (which could be duplicate test results), the last viral load test in 2016 was assessed to ensure sustained viral suppression. A total of 436 clients with only one viral load test from 2016-2017 were removed.

Statistical analysis

Collinearity between all variables was first assessed to circumvent redundancy. High correlation was observed between variables US born and preferred language (0.71) and between homicide and residential instability index (0.70). Homicide was also removed from the final model, as residential instability is a better measure of neighborhood dynamics. A sensitivity analysis was conducted by replacing residential instability with homicide. Bivariate analysis was conducted using chi-squared test for categorical variables and Wilcoxon rank sum tests for continuous variables since the data is not normally distributed.

Multilevel logistic regression models were used to examine the association between sustained viral suppression and individual and neighborhood level factors and

examine the moderating role of neighborhood indices. Four models were fitted for this analysis to evaluate estimates of the multilevel model independently. To assess intraclass correlation (ICC), the first model was an unconditional random intercept model with ZIP code random effects. ICC is a measure of clustering effect used to determine if a multilevel model is necessary. The second model included the individual level variables (demographic and psychosocial indices). The third model included variables from the second model and neighborhood level indices. Finally, the fourth model included all variables from the third model as well as the interaction terms between race/ethnicity and neighborhood indices. All statistical analyses were performed using SAS 9.4. This study was approved by the Florida International University Institutional Review Board.

Results

The study sample was comprised of 6491 people, of whom 58% were Hispanic, 24% non-Hispanic Black (NHB), 11% Haitian, and 7% non-Hispanic White (NHW). Non-Hispanic Blacks were less likely to achieve sustained viral suppression (70.4%) than Hispanics (85.7%), Haitians (74.1%) and NHW (84.5%), (p-value <0.0001). Table 1 shows the results of the bivariate analysis of each variable by sustained viral suppression. The largest percentage of population was ≥50 years old, males, not US born, household income of <100% FPL, MSM, without an AIDS diagnosis, had a provider with ≥ 200 RWP clients, not ACA recipient, and resided in neighborhoods of high SES disadvantage (35.8%), high residential instability (35.3%), and high racial/language homogeneity (33.9%). Among the racial/ethnic groups, Hispanics were only significantly associated with neighborhood indices. Hispanics in low, moderate, and high SES disadvantaged, residential instability and racial/language homogeneity neighborhoods were more likely to achieve sustained viral suppression (Table 1). The

psychosocial indices were all significantly associated with sustained viral suppression across all racial/ethnic groups, except Haitians.

Table 2 shows the results of the fitted multilevel models. Model 1 was the unconditional random intercept model, which calculated an ICC of 0.04. This indicates that 4% of the variation in sustained viral suppression is explained by the variation in neighborhoods or that the expected correlations between individuals in the same neighborhood is 4%. Model 2 shows the results of the model with only the individual level variables. This shows that NHB and Haitians vs NHW, 18-49 vs ≥50, household incomes <100% FPL vs ≥200% FPL, unknown vs. ≥200 provider's RWP client load, and having higher psychosocial indices value (poor mental health, high alcohol/drug use, and low income/SES) had lower odds of achieving sustained viral suppression (Table 2). Recipients of ACA had higher odds of sustained viral suppression than no ACA recipients (Table 2).

Model 3 illustrates that none of the neighborhood indices were significantly associated with sustained viral suppression after adjusting for individual level factors. Finally, model 4 shows the interaction between race/ethnicity and neighborhood indices and displays the significant findings for the difference in race/ethnicity within each neighborhood tertiles. In low SES disadvantaged neighborhoods, NHB had a lower odd of sustained viral suppression (adjusted odds ratio [aOR]: 0.39; 95% confidence interval [CI]: 0.20-0.74) compared to NHW in low SES disadvantaged neighborhoods. Haitians had lower odds of sustained viral suppression (aOR: 0.42; 95% CI: 0.18-0.97) in moderate SES disadvantaged neighborhoods when compared to NHW in moderate SES disadvantaged neighborhoods. Lower odds of sustained viral suppression were observed for NHB (aOR: 0.31; 95% CI: 0.15-0.65) in moderate residential instability neighborhoods compared to NHW in same neighborhoods. Finally, NHB exhibited lower

odds of sustained viral suppression in neighborhoods with low and high racial/language homogeneity (aOR: 0.38; 95% CI: 0.16-0.88) and (aOR: 0.49; 95% CI: 0.38-0.75), respectively, when compared to NHW in the same neighborhoods. Additionally, Haitians residing in neighborhoods with high racial/language homogeneity had lower odds of sustained viral suppression (aOR: 0.38; 95% CI: 0.19-0.75) when compared to NHW in the same neighborhoods.

Discussion

Our study analyzed RWP data to measure the influence of neighborhood factors on the association between race/ethnicity and sustained viral suppression, finding several significant effects. Haitians and NHB exhibited lower odds of sustained viral suppression when compared to NHW. While neighborhood level factors were overall not associated with sustained viral suppression, in neighborhoods with low or moderate SES disadvantage and residential instability, NHB and Haitians compared to NHW had lower odds of sustained viral suppression. Lastly, in neighborhoods with low or high racial/language homogeneity, NHB and Haitians had lower odds of sustained viral suppression compared to NHW.

After controlling for individual level factors, we did not observe an overall association between neighborhood level factors and sustained viral suppression. Factors influencing sustained viral suppression might be different, relative to other HIV care outcomes such as retention in care, and viral suppression. Maintaining a sustained viral load could prompt unique challenges, such as medication fatigue and drug resistance that could attribute to poor adherence over time. Additionally, perhaps individual level factors are more important predictors than neighborhood factors for sustained viral suppression. Notably, our study found differences in rates of sustained viral suppression within neighborhood characteristics for different racial/ethnic groups. Haitians and NHB

in moderate and low SES disadvantage neighborhoods respectively, had lower odds of sustained viral suppression when compared to NHW residing in same neighborhoods. These findings are in contrast with some prior literature which states that residents in more disadvantaged neighborhoods have lower rates of HIV care outcomes,(Wiewel et al. 2017b) when compared to more affluent neighborhoods. Even though SES is a strong predictor of poor health outcomes, racial disparities between Blacks and Whites, are also prominent among wealthier populations (Colen et al. 2018; Reardon, Fox, and Townsend 2015). The presence of acute and chronic discrimination experienced by high-income Blacks residing in integrated neighborhoods (Colen et al. 2018), could affect their stress responses and explain poor health outcomes observed in our study. Additionally, similar earning high income minorities and Whites do not reside in comparable neighborhoods, due to lack of generational wealth, systemic discrimination in housing, and racial segregation (Reardon, Fox, and Townsend 2015), which further worsens differences in achieving optimal health outcomes.

Neighborhoods characterized by residential instability have been associated with poor health outcomes (Browning and Cagney 2002b). Our study found that NHB in neighborhoods with moderate residential instability had lower odds of sustained viral suppression. We observed similar results in a post hoc analysis, where homicide was included instead of residential instability in the final model (since it was originally removed due to correlation). This showed that NHB in neighborhoods with moderate and high homicides had lower odds of achieving sustained viral suppression. Regardless of low or high neighborhoods' racial/language homogeneity, NHB's had lower odds of sustained viral suppression, while Haitians had lower odds of sustained viral suppression in neighborhoods with high racial/language homogeneity. Racial residential segregation among racial/ethnic minorities leads to economic deprivation, which

contribute to negative health consequences (Krieger 2001). In addition, irrespective of socioeconomic composition, Black neighborhoods are isolated and located in areas of severe disadvantage (Reardon, Fox, and Townsend 2015). Conversely, even though integration of neighborhoods might result in decreased bias and favorable perception of minorities due to increased exposure and interaction, Blacks face less discrimination and prejudice in homogenous neighborhoods (Crockett et al. 2019). Discrimination and stigma, including enacted (Algarin et al. 2020) and cumulative enacted stigma (Kalichman et al. 2020) are posited to affect minority populations and lead to negative health consequences (Pellowski et al. 2013).

Individual level characteristics were also associated with lower odds of sustained viral suppression. Compared to Hispanics and Whites, Blacks have a lower rate of sustained viral suppression and experience more treatment-related disparities (Crepaz et al. 2018b). Haitians carry a disproportionate burden of HIV amongst Caribbean-born Blacks in South Florida and are less likely to be linked care and retained in continuous care (Cyrus et al. 2017a), which subsequently affects sustained viral suppression. Younger adults experience worsening viral load status from first to last viral load (Crepaz et al. 2017b), and have higher risk of viral rebound (Palmer et al. 2018), which affects achieving sustained viral load. Poverty has also been associated with poor health outcomes (Cohen et al. 2016), while having an AIDS diagnoses indicate higher viral load and belonging in transitional care (Olatosi et al. 2009). Our findings also indicate that clients who did not know their provider's name had poor rates of sustained viral suppression. Not knowing a physician's name might be an indication of the poor quality of relationship that the provider has with the patient, which is instrumental for treatment adherence, retention in care, and ultimately viral suppression (Earl et al. 2013). This could also be due to having a new provider or receiving care in a group clinic, where the

client doesn't see the same provider during each visit. The presence of psychosocial factors such as depression, anxiety, domestic violence, drug/alcohol use on poor outcomes of medication adherence, retention in care, and viral suppression has been well noted in prior literature (Sullivan, Messer, and Quinlivan 2015). Additionally, income-related disparities such as lack of access to work and homelessness have also been associated with negative HIV care outcomes (Thakarar et al. 2016). Conversely, adults enrolled in ACA had a higher odd of sustained viral suppression. Clients with income <100% of the FPL and with an undocumented status are ineligible to receive ACA benefits. Hence, the ACA client population are less socially disadvantaged as they have higher incomes and access to comprehensive medical coverage through the ACA (McManus et al. 2016).

This study is not without its limitations. First, due to the cross-sectional nature of this study, there might be residual confounding from variables that were not assessed in this study. Second, using ZIP codes to define neighborhoods can lead to spatial misclassification, as individuals encounter numerous neighborhoods beyond the geographic boundary of ZIP codes (Duncan et al. 2014). Third, the use of indices to characterize neighborhoods might prohibit identifying pertinent neighborhood factors that might be associated with sustained viral suppression. Finally, all PWH in our study are engaged in care in the RWP in Miami-Dade county, which has a majority non US-born and Hispanic population. Consequently the findings might not be generalizable to individuals who are not engaged in care, not enrolled in the RWP or other programs such as Medicare/Medicaid, employer-based and private insurance, and residents of other geographic areas. Additionally, we conducted a sensitivity analysis to assess the robustness of the exclusion of individuals with only one suppressed viral load in our definition of sustained viral suppression and found similar results.

Conclusion

Overall, we observed clients enrolled in the RWP had achieved high rates of sustained viral suppression. However racial/ethnic disparities existed across various individual and neighborhood characteristics, particularily among minorities who carry a higher disease burden. Moreoever racial/ethnic minorities and socieconomically disadvantaged communities were disproproationalty affected by COVID-19 pandemic (Karmakar, Lantz, and Tipirneni 2021), which may further exasperate HIV disparities and care outcomes among minorities in these communities. Hence, it is important to continue to study neighborhood level factors that might be potential barriers to achieving a consistent viral load, especially for racial/ethnic minorities. Additionally, examining mechanisms for the association between neighborhood factors and racial/ethnic disparities in sustained viral suppression is imperative to implement structural and community-wide interventions.

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Table 1: Descriptive characteristics of sustained viral suppression for Ryan White HIV/AIDS Program clients by Race/ethnicity, in Miami, Florida, 2017

	Total N (%)	Non-Hispanic Black			Hispanic			Haitian			Non-Hispanic White		
		Not sustained N (%)	Sustained N (%)		Not sustained N (%)	Sustained N (%)		Not sustained N (%)	Sustained N (%)		Not sustained N (%)	Sustained N (%)	
Total		**N= 1579**			**N= 3771**			**N= 710**			**N= 431**		
				p-value			**p-value**			**p-value**			**p-value**
Age				**<0.0001**			**0.0005**			**<0.0001**			**0.0021**
18–34	1423 (21.9)	162 (41.4)	229 (58.6)		154 (17.9)	708 (82.1)		34 (39.1)	53 (60.9)		17 (20.5)	66 (79.5)	
35–49	2504 (38.6)	147 (31.5)	320 (68.5)		233 (14.3)	1404 (85.8)		75 (31.4)	164 (68.6)		34 (21.2)	127 (78.8)	
≥50	2564 (39.5)	158 (21.9)	563 (78.1)		151 (11.8)	1121 (88.1)		75 (19.5)	309 (80.5)		16 (8.6)	171 (91.4)	
Gender				0.1276			0.0966			0.6429			0.0938
Males	4988 (76.8)	298 (31.0)	664 (69.0)		461 (13.9)	2852 (86.1)		89 (26.7)	244 (73.3)		55 (14.5)	325 (85.5)	
Female	1503 (23.2)	169 (27.4)	448 (72.6)		77 (16.8)	381 (83.2)		95 (25.2)	282 (74.8)		12 (23.5)	39 (76.5)	
US Born				**0.0026**			**0.0037**			0.0914			0.6428
No	4405 (67.9)	42 (20.6)	162 (79.4)		469 (13.7)	2946 (86.3)		166 (25.2)	494 (74.9)		18 (14.3)	108 (85.7)	
Yes	2086 (32.1)	425 (30.9)	950 (69.1)		69 (19.4)	287 (80.6)		18 (36.0)	32 (64.0)		49 (16.1)	256 (83.9)	
Household Income (FPL)				**<0.0001**			**<0.0001**			0.0694			**<0.0001**
≥200%	1516 (23.4)	41 (17.6)	192 (82.4)		90 (8.7)	942 (91.3)		25 (21.6)	91 (78.4)		7 (5.2)	128 (94.8)	
100%–199%	2303 (35.5)	120 (23.6)	389 (76.4)		160 (11.5)	1230 (88.5)		58 (22.7)	198 (77.3)		21 (14.2)	127 (85.8)	

<100%	2672 (41.2)	306 (36.6)	531 (63.4)		288 (21.4)	1061 (78.7)		101 (29.9)	237 (70.1)		39 (26.4)	109 (73.7)	
Mode of Transmission				0.5573			**0.0005**			**0.0091**			0.1826
Hetero-sexual	2887 (44.5)	320 (28.7)	792 (71.2)		169 (16.1)	879 (83.9)		160 (24.6)	491 (75.4)		15 (19.7)	61 (80.3)	
MSM	3359 (51.8)	122 (31.6)	264 (68.4)		341 (13.1)	2266 (86.9)		14 (35.0)	26 (65.0)		45 (13.8)	281 (86.2)	
IDU+ Other	245 (3.8)	25 (30.9)	56 (69.1)		28 (24.1)	88 (75.9)		10 (52.6)	9 (47.4)		7 (24.1)	22 (75.8)	
AIDS Diagnosis				**0.0005**			**<0.0001**			**0.0191**			0.2311
No	3828 (59.0)	206 (25.7)	597 (74.4)		290 (12.0)	2131 (88.0)		66 (21.5)	241 (78.5)		42 (14.1)	255 (85.9)	
Yes	2663 (41.0)	261 (33.6)	515 (66.4)		248 (18.4)	1102 (81.6)		118 (29.3)	285 (70.7)		25 (18.7)	109 (81.3)	
Provider's RWP Client Load				**0.0004**			**0.0015**			0.1065			**0.0196**
1–99	1690 (26.0)	118 (25.4)	346 (74.6)		136 (17.7)	634 (82.3)		90 (28.4)	227 (71.6)		11 (7.9)	128 (92.0)	
100–199	1939 (29.9)	199 (32.1)	422 (67.9)		125 (13.4)	817 (86.7)		63 (23.2)	209 (76.8)		18 (17.3)	86 (82.7)	
≥200	2510 (38.7)	106 (26.8)	290 (73.2)		239 (12.8)	1624 (87.2)		21 (21.7)	76 (78.4)		30 (19.5)	124 (80.5)	
unknown	352 (5.4)	44 (44.9)	54 (55.1)		38 (19.4)	158 (80.6)		10 (41.7)	14 (58.3)		8 (23.5)	26 (76.5)	
ACA				**0.0031**			**<0.0001**			0.0939			0.2488
No	5521 (85.1)	445 (30.6)	1011 (69.4)		484 (15.8)	2587 (84.2)		169 (26.9)	459 (73.1)		60 (16.4)	306 (83.6)	
Yes	970 (14.9)	22 (17.9)	101 (82.1)		54 (7.7)	646 (92.3)		15 (18.3)	67 (81.7)		7 (10.8)	58 (89.2)	
Psychosocial Indices: Mean and Standard Deviation (SD)													
Mental health index				**<0.0001**			**<0.0001**			0.6446			**0.0001**
Mean		0.46	0.11		0.22	-0.12		-0.28	-0.35		0.78	0.06	
SD		1.26	1.09		1.15	0.87		0.75	0.51		1.58	1.05	

Substance use index			**<0.0001**			**<0.0001**			0.3804			**0.0015**
Mean		0.50	0.08		0.18	-0.14		-0.26	-0.22		0.51	0.05	
SD		1.57	1.11		1.28	0.70		0.12	0.48		1.61	1.07	
Income/SES index			**<0.0001**			**<0.0001**			0.2514			**<0.0001**
Mean		0.66	0.22		0.11	-0.25		0.07	-0.06		0.55	-0.7	
SD		1.35	1.01		1.09	0.77		1.04	0.84		1.38	0.95	
Neighborhood Indices:													
SES disadvantage index				0.6888			**0.0006**			0.2810			0.1237
Low	2207	72	174		206	1434		15	65		31	210	
	(34.0)	(29.3)	(70.7)		(12.6)	(87.4)		(18.7)	(81.3)		(12.9)	(87.1)	
Moderate	1960	119	305		151	964		87	230		17	87	
	(30.2)	(28.1)	(71.9)		(13.5)	(86.5)		(27.4)	(72.6)		(16.4)	(83.7)	
High	2324	276	633		181	835		82	231		19	67	
	(35.8)	(30.4)	(69.4)		(17.8)	(82.2)		(26.2)	(73.8)		(22.1)	(77.9)	
Residential instability index				0.6184			**0.0107**			0.9060			0.2398
Low	2111	106	277		165	1207		69	207		11	69	
	(32.5)	(27.7)	(72.3)		(12.0)	(88.0)		(25.0)	(75.0)		(13.8)	(86.3)	
Moderate	2086	200	455		184	1026		32	89		11	89	
	(32.1)	(30.5)	(69.5)		(15.2)	(84.8)		(26.5)	(73.6)		(11.0)	(89.0)	
High	2294	161	380		189	1000		83	230		45	206	
	(35.3)	(29.8)	(70.2)		(15.9)	(84.1)		(26.5)	(73.5)		(17.9)	(82.1)	
Racial/language homogeneity index				0.1756			**0.0023**			0.7638			0.9260
Low	2128	25	52		244	1698		4 (19.1)	17		13	75	
	(32.8)	(32.5)	(67.5)		(12.6)	(87.4)			(80.9)		(14.8)	(85.2)	
Moderate	2163	200	427		182	1022		25	72		38	197	
	(33.3)	(31.9)	(68.1)		(15.1)	(84.9)		(25.8)	(74.2)		(16.2)	(83.8)	
High	2200	242	633		112	513		155	437		16	92	
	(33.9)	(27.7)	(72.3)		(17.9)	(82.1)		(26.2)	(73.8)		(14.8)	(85.2)	

Bivariate analysis conducted using chi-square test for categorical variable and Wilcoxon rank sum test for continuous variables.

Table 2 Multi-level mixed effect models for sustained viral suppression for Ryan White HIV/AIDS Program clients by Race/ethnicity, in Miami, Florida, 2017

	Model 1: Unconditional		**Model 2: Individual level factors**		**Model 3: Individual + neighborhood level factors**		**Model 4: All level factors + Interactions**	
	Estimate	**SE**	**Estimate**	**SE**	**Estimate**	**SE**	**Estimate**	**SE**
Intercept variance	0.1401	0.0391	0.00729	0.01154	0.00746	0.01231	0.01462	0.01566
ICC	0.04							
			OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Race/Ethnicity								
NHB vs. NHW			**0.59**	**(0.43, 0.81)**	**0.61**	**(0.44, 0.84)**	**0.48**	**(0.32, 0.73)**
Hispanic vs. NHW			0.95	(0.69, 1.31)	0.91	(0.66, 1.25)	0.82	(0.55, 1.21)
Haitian vs. NHW			**0.46**	**(0.32, 0.67)**	**0.47**	**(0.32, 0.69)**	**0.54**	**(0.30, 0.96)**
Age								
18–34 vs. 50+			**0.39**	**(0.32, 0.47)**	**0.39**	**(0.32, 0.47)**	**0.39**	**(0.32, 0.46)**
35–49 vs. 50+			**0.57**	**(0.49, 0.67)**	**0.58**	**(0.49, 0.68)**	**0.58**	**(0.49, 0.68)**
Gender								
Women vs. Men			1.11	(0.93, 1.33)	1.11	(0.93, 1.33)	1.11	(0.93, 1.33)
US Born								
Yes vs. No			0.88	(0.72, 1.08)	0.89	(0.73, 1.10)	0.89	(0.72, 1.09)
Household Income (FPL)								
100-199% vs. ≥200%			**0.76**	**(0.62, 0.93)**	**0.75**	**(0.61, 0.93)**	**0.76**	**(0.62, 0.93)**
<100% vs. ≥200%			**0.53**	**(0.43, 0.65)**	**0.53**	**(0.43, 0.65)**	**0.53**	**(0.43, 0.66)**
Mode of Transmission								
Heterosexual vs. MSM			0.89	(0.74, 1.07)	0.91	(0.75, 1.09)	0.92	(0.76, 1.10)
IDU vs. MSM			0.78	(0.56, 1.09)	0.78	(0.56, 1.08)	0.78	(0.56, 1.10)
AIDS Diagnosis								
Yes vs. No			**0.57**	**(0.49, 0.65)**	**0.57**	**(0.50, 0.65)**	**0.57**	**(0.50, 0.66)**

Provider's RWP Client Load						
1–99 vs. 200+	0.87	(0.73, 1.04)	0.88	(0.74, 1.05)	0.88	(0.74, 1.05)
100–199 vs 200+	0.92	(0.78, 1.08)	0.92	(0.78, 1.09)	0.93	(0.78, 1.09)
Unknown vs. 200+	**0.65**	**(0.49, 0.86)**	**0.64**	**(0.49, 0.85)**	**0.64**	**(0.48, 0.85)**
ACA						
Yes vs. No	**1.37**	**(1.09, 1.73)**	**1.36**	**(1.08, 1.71)**	**1.36**	**(1.08, 1.72)**
		Psychosocial Indices				
Mental health index	**0.84**	**(0.79, 0.89)**	**0.84**	**(0.79, 0.89)**	**0.84**	**(0.79, 0.90)**
Substance use index	**0.87**	**(0.82, 0.93)**	**0.87**	**(0.82, 0.93)**	**0.88**	**(0.83, 0.93)**
Income/SES index	**0.83**	**(0.78, 0.89)**	**0.83**	**(0.78, 0.90)**	**0.83**	**(0.77, 0.89)**
		Neighborhood Indices				
SES disadvantage index						
Moderate vs. Low			0.90	(0.74, 1.11)	0.80	(0.58, 1.10)
High vs. Low			0.91	(0.73, 1.13)	0.88	(0.62, 1.25)
Residential instability index						
Moderate vs. Low			0.91	(0.74, 1.10)	1.04	(0.75, 1.44)
High vs. Low			0.91	(0.74, 1.12)	0.82	(0.57, 1.17)
Racial/language homogeneity index						
Moderate vs. Low			0.82	(0.67, 1.01)	0.89	(0.58, 1.35)
High vs. Low			0.85	(0.68, 1.05)	0.93	(0.61, 1.41)
		Interactions				
SES disadvantage index						
Low (NHB vs. NHW)					**0.39**	**(0.20, 0.74)**
Low (Hispanic vs. NHW)					0.68	(0.37, 1.22)
Low (Haitian vs. NHW)					0.52	(0.22, 1.24)
Moderate (NHB vs. NHW)					0.53	(0.27, 1.02)
Moderate (Hispanic vs. NHW)					0.91	(0.48, 1.71)

Moderate (Haitian vs. NHW)	**0.42**	**(0.18, 0.97)**
High (NHB vs. NHW)	0.56	(0.27, 1.14)
High (Hispanic vs. NHW)	0.89	(0.44, 1.81)
High (Haitian vs. NHW)	0.71	(0.28, 1.79)
Residential instability index		
Low (NHB vs. NHW)	0.54	(0.25, 1.16)
Low (Hispanic vs. NHW)	1.00	(0.48, 2.09)
Low (Haitian vs. NHW)	0.72	(0.29, 1.78)
Moderate (NHB vs. NHW)	**0.31**	**(0.15, 0.65)**
Moderate (Hispanic vs. NHW)	0.54	(0.27, 1.11)
Moderate (Haitian vs. NHW)	0.44	(0.18, 1.09)
High (NHB vs. NHW)	0.67	(0.41, 1.11)
High (Hispanic vs. NHW)	1.01	(0.64, 1.59)
High (Haitian vs. NHW)	0.50	(0.24, 1.04)
Racial/language homogeneity index		
Low (NHB vs. NHW)	**0.38**	**(0.16, 0.88)**
Low (Hispanic vs. NHW)	0.88	(0.43, 1.78)
Low (Haitian vs. NHW)	0.61	(0.16, 2.37)
Moderate (NHB vs. NHW)	0.62	(0.34, 1.13)
Moderate (Hispanic vs. NHW)	1.01	(0.55, 1.86)
Moderate (Haitian vs. NHW)	0.67	(0.31, 1.46)
High (NHB vs. NHW)	**0.49**	**(0.26, 0.93)**
High (Hispanic vs. NHW)	0.62	(0.32, 1.19)
High (Haitian vs. NHW)	**0.38**	**(0.19, 0.75)**

Supplemental Table 1: Psychosocial and Neighborhood level variables used for indices

	Index	Variables
Psychosocial Indices (Ryan White Program dataset)	Mental Health index	Feeling depressed or anxious Receives or needs mental health services Ever experienced domestic violence
	Substance use index	Drug use Drug/alcohol use resulted in any problem in daily activity or legal issue or hazardous situation
	SES/Income index	Work status Homelessness status
Neighborhood Indices (American Community Survey dataset)	Socioeconomic disadvantage index	Percent of households receiving public assistance in the past 12 months for household Percent of households without access to a car Percent of households with ≥ 1 person per room Percent of people living below the federally defined poverty line Percent of owner-occupied home worth less than or equal to $300,000 Percent of households with annual income < $15,000 Percent of households with annual income less than or equal to $150,000 Income disparity- derived from percent of households with annual income < $10,000 and percent of households with annual income ≥ $50,000 Percent of population aged 25 and over with less than 12th grade education Percent of population aged 25 and over without a graduate or professional degree Percent of population age 16 and over who are unemployed Percent of population aged 16 and over not employed in high working-class occupations (ACS occupation group: ‘‘managerial, business, science, and arts occupations’’)
	Residential instability index	Percent of the population moved within same county Percent of households living in rented house
	Racial/language homogeneity index	Percent Non-Hispanic Black Percent speak English well for all populations

MANUSCRIPT 2

Factors Associated with Geographic Patterns of Poor Sustained Viral Suppression in Miami-Dade County Florida, 2017

Abstract

Identifying geographic locations most affected by the HIV epidemic is essential to addressing disparities that impact people living with HIV. This study sought to identify individual and neighborhood level factors that are associated with residing in geographic hotspots of poor sustained HIV viral suppression. Using data from the Miami-Dade County Ryan White HIV/AIDS program, spatial autocorrelation of poor sustained viral suppression (at least 1 laboratory test ≥200 copies/mL in 2017) was investigated using Global Moran's I followed by Local Moran's I and Getis Ord Gi* statistics by ZIP code tabulation areas (ZCTAs). Subsequently, multivariable logistic regression analysis was conducted to identify factors associated with residing in geographic hotspots of poor sustained viral suppression. Several ZCTAs in the northern part of the county, accounting for 1/3 of the Ryan White program clients, had significantly higher clustering of poor sustained viral suppression. Client-level sociodemographic characteristics such as race/ethnicity, age, and poverty, and neighborhood-level characteristics (socioeconomic disadvantage index, residential instability index, and racial/language homogeneity index) were significantly associated with living in a hotspot of poor sustained viral suppression. These findings highlight that spatial variation in sustained viral suppression exists within the county. Targeted strategies that address structural factors and the needs of people with HIV living in specified geographic areas may improve their HIV health outcomes, and contribute towards local, regional, and national goals of ending the HIV epidemic.

Introduction

Achieving sustained viral suppression, defined as having <200 copies/ml on all viral load test results over the course of a year (Crepaz et al. 2018b; Sheehan et al. 2020), is critical for people with HIV (PWH). Unlike the single viral load measure, examining sustained viral suppression indicates continuous suppression throughout a year, providing a better understanding of viral load over time(Marks et al. 2015; Mugavero et al. 2011; Terzian et al. 2012). Sustained VL suppression decreases the risk of onward transmission, curtails disease progression to AIDS, and reduces mortality (Crawford and Thornton 2017a; Crepaz et al. 2017b; Jefferson et al. 2017; Marks et al. 2016a) from opportunistic infections. Improving the overall health outcomes for PWH. In a study of national HIV surveillance data, PWH who did not achieve sustained viral suppression spent on average 60% of a two-year period with viral load counts of >200 copies/ml (Crepaz et al. 2016). Additionally, examining sustained viral load allows for a better understating of the changes in viral suppression status that occur within a year and that may lead to HIV transmission (Crepaz et al. 2016; Marks et al. 2016a; Crawford and Thornton 2017a). In order to achieve the goals of the National HIV/AIDS strategy of ending the HIV epidemic(US Department of Health and Human Services 2021) and support the Undetectable=Untransmittable (U=U) concept (Eisinger, Dieffenbach, and Fauci 2019), sustained viral suppression should be considered an important component of the HIV care continuum.

Social and structural factors within specified geographic areas or neighborhoods play an important role in HIV care outcomes (Ransome et al. 2016), including achieving sustained viral suppression. Geographic information system (GIS) tools have been used to identify patterns and hotspots of disease burden, as well as to map health disparities and assess proximity of care and resources (Eberhart et al. 2013a). These GIS tools are

also used to highlight the distribution of various sociodemographic characteristics of neighborhoods which influence optimal health outcomes. Previous studies have identified geographic clustering of areas with low linkage to HIV care, low retention in HIV care, and low viral suppression (Goswami et al. 2016),(Das et al. 2018). Suboptimal rates of HIV care outcomes within geographic areas are linked to high HIV prevalence communities, decreased community-level viral suppression, and increased risk of disease acquisition at the community level (Ransome et al. 2017a). Additionally, geographic hotspots of poor HIV outcomes are associated with high poverty, income inequality (Ransome et al. 2017b) crime, lack of access to resources and transportation, and housing instability (Eberhart et al. 2013a; Rebeiro et al. 2018). Adverse neighborhood-level socioeconomic factors of high poverty, low educational attainment, and residential segregation have been associated with poor medication adherence, increased risky behavior, higher AIDS-related mortality, decreased access to HIV care resources, and lack of viral suppression,(Burke-Miller et al. 2016; Eberhart et al. 2015b; Rebeiro et al. 2018; Shacham et al. 2013) which ultimately affects the rate of sustained viral suppression.

In particular, southern states in the United States (US) have predominantly observed high disease burden as well as poor HIV care and treatment outcomes (Rebeiro et al. 2018). In 2017, Miami-Dade County in Florida had one of the highest rates of HIV incidence and prevalence of any metropolitan statistical areas in the US (Centers for Disease Control and Prevention 2019a, 2018a), a position it has held since 2010 (Centers for Disease Control and Prevention 2020). Due to the high number of infections, the county is one of the 57 geographic focus areas that receives additional resources and support as part of National HIV/AIDS strategy's *Ending the HIV Epidemic: Plan for America* strategic goal (US Department of Health and Human Services 2020).

Approximately 28,000 PWH reside in the county, with only 60.1% achieving viral suppression (AIDS Vu 2021). In 2017, Rojas et al. found that, 40% of PWH in the county were either out of HIV care or not virally suppressed (Rojas et al. 2020). Moreover, numerous studies have shown disparities along the care cascade including, unfavorable outcomes in retention in care, viral suppression, and sustained viral suppression for gender, racial/ethnic, and sexual minority groups in Miami-Dade County (Sheehan et al. 2020; Sheehan et al. 2017a; Trepka et al. 2020b).

This combination of the highest HIV rates among metropolitan areas in the country and a racially/ethnic diverse population with the highest proportion of non-white residents of any metropolitan area in the US (US Census Bureau 2019), Miami-Dade County serves as a valuable setting for examining geographic disparities and identifying risk factors of sustained viral suppression. Also, to our knowledge no study has examined geographic areas of sustained viral suppression and factors that influence residing in these geographic locations. Hence, the objective of this study was to identify individual and neighborhood level factors that are associated with residing in geographic hotspots of poor sustained viral suppression in Miami-Dade County in 2017. We hypothesize that residing in a geographic hotspot of poor sustained viral suppression is associated with higher neighborhood-level disadvantage and racial/ethnic minorities.

Methods

Study Population and Dataset

Individual-level demographic, psychosocial, and laboratory data were collected for adults ≥18 years of age enrolled in the Miami-Dade County Ryan White Program (RWP) in 2017. Enrolled clients were defined as receiving medical case management services, including peer education support through the RWP during that year. The federally funded RWP is the payer of last resort for HIV medical and support services for

over 9,000 low-income PWH in Miami-Dade County each year, providing medical case management, outpatient primary and specialty medical care, antiretroviral medications, oral health care, and numerous other services (e.g., premium and co-pay support for clients receiving medical care through the Affordable Care Act, transportation services, mental health services and substance abuse care). At the time the study data were collected, the RWP standard of care was to conduct twice-yearly evaluations of the care needs of clients, their viral load levels, and their health care environments. If a client had a missing health assessment or laboratory test results, they were excluded from the analysis. Additionally, clients were also excluded if they only had received ancillary support services from the RWP and those with closed cases due to relocation, mortality, or financial ineligibilities. Neighborhood level demographic, social, and economic data were extracted from the American Community Survey by ZIP code tabulated areas (ZCTAs) (Census Data 2017). Homicide index for each ZIP code was collected from Simply Analytics (Simply Analytics 2019). A total of 75 ZCTAs were used in this study after excluding ZCTAs that were commercial zones.

Predictors and Outcomes

Individual-level predictors included age, gender, US birth status, self-reported primary mode of HIV exposure for males and females, presence or absence of an AIDS diagnosis, household income as a percentage of the federal poverty level (FPL), HIV medical provider's RWP client load, and psychosocial indices (mental health index, substance use index, and income/SES index). These indices were created using principal component analysis, where a continuous score was calculated for each index based on the linear combination of the observed weights of the variables.

Neighborhood level predictors included homicide index and three indices (socioeconomic [SES] disadvantage index, residential instability index, racial/language

homogeneity index). The three neighborhood indices were created using similar methods as those used to create the psychosocial indices and derived from 24 variables, including income, poverty, education, occupation, racial/ethnic composition, immigration status, language proficiency, and residential mobility. The first index was the SES Disadvantage Index: this measure was comprised of 12 variables (public assistance, vehicle ownership, crowding, poverty, homeownership valued at ≤300,000, annual income ≤$150,000, income disparity [derived from percent of households with annual income <$10,000 and percent of households with annual income ≥$50,000], annual income <15,000, less than high school education, less than a graduate professional degree, unemployment, and not working in high-class occupations such as managerial, business, science, and arts occupations). The factor loadings for the 12 variables were between 0.54 and 0.89. The second index, Residential Instability Index, had two variables (rented housing and "population that moved within the same county"), with factor loadings 0.65 and 0.75 respectively. The third index, Racial/language Homogeneity Index, had two variables (percent non-Hispanic Black, and English language proficiency) with factor loadings 0.75 and 0.78 respectively). A higher index score for each index indicates increased social disadvantage conditions.

The outcome of interest for this analysis was residing in geographic hotspots of poor sustained viral suppression (Yes/No). Poor sustained viral suppression was defined as having plasma viral load ≥200 copies/ml in any of the client viral load tests during 2017. Rates of poor sustained viral suppression by ZCTAs were used to identify geographic areas of poor sustained viral suppression. The outcome of interest (geographic hotspots of poor sustained viral suppression) was calculated based on the results of the Getis Ord-Gi* statistics and was used in the regression analysis.

Statistical analysis

Detection of poor sustained viral suppression hotspots

Global Moran's I, implemented in ArcGIS 10.8, was first used to detect significant spatial autocorrelation or dependency of poor sustained viral suppression using a row-standardized first-order Queen spatial weight matrix. Moran's I is used to assess whether a geographic pattern observed is clustered, dispersed, or random and has a value between 1 and -1. Values greater than 0 indicate that the global pattern is trending towards positive spatial autocorrelation (neighbors have similar high or low values), value less than 0 indicate that the global pattern is trending towards negative spatial autocorrecation (neighbors have dissimilar values) and a value closer to zero trends towards spatial randomness. The first-order Queen spatial weights were used to define neighborhoods based on whether a polygon shares an edge or corner/vertex with a specified polygon. Subsequently, Local Indicators of Spatial Association (LISA) or Local Moran's I were computed to identify the locations of significant clusters and outliers of poor sustained viral suppression. This classified the clusters into values of high values next to high values (HH) and low values next to low values (LL), and outliers into high values next to low values (HL) and low values next to high values (LH). Nine hundred ninety-nine Monte Carlo replications were completed to assess statistical significance and the null hypothesis of a given ZCTA not being part of a cluster was rejected when the simulated p-value was less than 0.05. Lastly, hotspot analysis was conducted using the local Getis-Ord Gi* statistics to assess robustness, which indicates the intensity of the clusters for each neighbor based on the statistical significance of Z-score for each ZCTA. ZCTAs with p-value <0.05 were considering in the regression analysis. All cartographic manipulations were conducted using ArcGIS 10.8.

Analytical Plan

Descriptive statistics were conducted for all variables. We tested for differences in groups using chi-squared test for categorical variables and Wilcoxon rank-sum test for continuous variables (psychosocial and neighborhood indices). Two multivariable logistic regression models were used to assess the association between demographic, psychosocial, and neighborhood-level characteristics and the clients' residing in geographic hotspots of poor sustained viral suppression. The first model included only individual-level variables such as demographic and psychosocial indices. To test the influence of neighborhood-level indices on the outcome, we successively included the neighborhood level- indices in a second model. Adjusted odds ratio and 95% confidence intervals were computed. All statistical analyses were conducted using SAS 9.4.

Results

Spatial Distribution

Results from the Global Moran's I showed a positive autocorrelation (Moran's I Index: 0.251; z-score; 3.958934; p-value:0.0000075) for poor sustained viral suppression rates, indicating that there is a presence of overall clustering across the ZCTAs in Miami-Dade County. The Local Moran's I showed significant local clusters in various parts of the county. Hotspot (HH) of poor sustained viral suppression were observed in 10 ZCTAs located in the north-central and one ZCTA in the southern part of the county (Figure 1: Map A). Cold spots of clusters (LL) were observed in two ZCTAs in the north-western and south-eastern parts of the county. Spatial outliers (HL and LH) were observed in four ZCTAs in the western part of the county as well as one ZCTAs in the southern and eastern part of the county. Results from the Getis Ord-Gi* statistics showed the significant hotspots and cold-spots with p-values of <0.1, <0.05, and <0.01, highlighting the intensity of the clusters (Figure 1: Map B). Four ZCTAs in the north-central part of the county had a significant hotspot (p-value<0.01) surrounded by six

ZCTAs with significance of <0.05. Two ZCTAs, one located in the northern part of the county and the other in the south-western part of the county, had hotspots clusters of p-value <0.1. Only one cold-spot (p-value <0.05) was observed in the northern part of the county, while 5 other ZCTAs spread through the northern, central, and eastern part of the county had significant cold spot clusters (p-value <0.1). Based on the results of the Getis Ord-Gi* statistics, a total of 10 hotspot ZCTAs with p-value <0.05 were deemed geographic hotspots of poor sustained viral suppression in 2017, while other ZCTAs that did not either exhibit significant clustering or were cold spots were categorized as other geographic areas. Getis Ord- Gi* includes the value of the feature being analyzed in addition to the neighborhoods features during the analysis and assess significance by standardizing z-values.

Bivariate Analysis

A total of 6491 people in the 2017 RWP data set were included in this analysis. The population was comprised of 58% Hispanics, 24% Non-Hispanic Blacks (NHB), 11% Haitians and 7% Non-Hispanic White/Others (NHW). Twenty-three percent of persons residing in geographic hotspots of poor sustained viral suppression had not achieved sustained viral suppression, while 16.2% of persons residing in other geographic area did not have sustained viral suppression. The majority of the clients residing in geographic hotspots of poor sustained viral suppression were NHB, were ≥ 50 years of age, were male, were foreign born, were not enrolled in ACA, had a household income <100% FPL, had a heterosexual mode of HIV exposure, did not have an AIDS diagnosis, and had a HIV provider with 100-199 RWP clients. Conversely, Hispanics, those <49 years of age, males, those who were foreign born, those with household income between 100-199% of FPL, those with men who have sex with men (MSM) mode of HIV exposure, those with no AIDS diagnosis, those with HIV provider who has

≥200 RWP clients, and those not enrolled in ACA were more likely to reside in other geographic areas [no clustering or cold spots] (Table 1). In the bivariate analyses, all variables were associated with residing in geographic hotspots of poor sustained viral suppression. People living in neighborhood with higher SES disadvantage, residential instability, racial/language homogeneity (high % NHB and English-speaking concentration), and homicide rates were more likely to reside in geographic hotspots of poor sustained viral suppression.

Multivariable Analysis

The multivariable logistic regression results showed that in the model with only individual-level characteristics, NHB vs. NHW (adjusted odds ratio [aOR]: 2.83; 95% confidence interval [CI]: 2.20-3.65), Haitians vs. NHW (aOR: 4.68; 95% CI: 3.43-6.38), US-born vs. foreign-born (aOR: 1.26; 95% CI: 1.05-1.51), and heterosexual vs MSM mode of HIV transmission (aOR: 1.61; 95% CI: 1.37-1.88) had higher odds of residing in geographic hotspots of poor sustained viral suppression. Higher mental health index score (worse mental health symptoms) was associated with residing in geographic hotspots of poor sustained viral suppression (aOR: 1.12; 95% CI: 1.06-1.19), while 18–34-year-olds had a lower odd of residing in geographic hotspots of poor sustained viral suppression when compared to ≥ 50 years of age (aOR: 0.82; 95% CI: 0.70-0.97) (Table 2). Model 2 contains individual and neighborhood level factors and demonstrates that Haitians vs. NHW (aOR: 2.22; 95% CI: 1.40-3.52) had higher odds of residing in geographic hotspots of poor sustained viral suppression. The odds of residing in geographic hotspots of poor sustained viral suppression increased by 9.13 times for every one unit increase in SES disadvantage index, 5.35 times for every one unit increase in residential instability index, and 8.55 times for every one unit increase in

racial/language homogeneity index. Individuals younger than 50 had lower odds of residing in hotspots of poor sustained viral suppression (Table 2).

Discussion

This study sought to identify geographic hotspots of poor sustained HIV viral suppression among RWP enrollees in Miami-Dade County, and factors associated residing in these areas. Our findings demonstrate that spatial patterns of poor sustained viral suppression were aggregated in 12% (10) of ZCTAs; mostly in the northern part of the county, where approximately 33% of the RWP clients reside. Various demographic and neighborhood-level factors were associated with residing in these geographic hotspots, indicating the co-occurring influence of individual/interpersonal and social/structural-level factors on achieving optimal care outcomes. People residing in these hotspots were more likely to be racial/ethnic minorities, older, living in poverty, and with mental health symptoms. Additionally, neighborhood-level measures of social disadvantage were also associated with residing in geographic hotspots of poor sustained viral suppression.

Miami-Dade County has a majority Hispanic (69%) and immigrant population (US Census Bureau 2019). However, Blacks/African Americans account for the lowest proportion of PWH that have achieved viral suppression (52%) compared to Hispanics (66%) and Whites (64%) (AIDS Vu 2021).The 10 ZCTAs identified as geographic hotspots of poor sustained viral suppression are in the northern part of the county and primarily encompass Liberty City, Little Haiti, North Miami, and the surrounding neighborhoods. While most of the county's population are Hispanic, these areas are comprised of a large percentage of people who are Black/African American, are US born, speak another language besides English, who live in poverty. For Blacks and marginalized populations, racially segregated neighborhoods have limited social,

economic, and political resources, which are key drivers to attaining better health outcomes (Kerr et al. 2015a). Even though approximately 80% of HIV service providers including RWP funded programs are located in these areas (Ganapati et al. 2010), these locations experiences a higher burden of poor sustained viral suppression. Sociodemographic and economic factors might have more of a detrimental influence on achieving sustained viral suppression that cannot be alleviated by access to care alone.

When only examining individual level characteristics, we observed that NHB and Haitians had higher odds of residing in ZCTAs with poor sustained viral suppression. Studies have shown that racial/ethnic minorities are disproportionately affected by poor HIV care outcomes, including lack of sustained viral suppression (Crepaz et al. 2018b). When compared to Hispanics and NHW, NHB have a lower rate of sustained viral suppression (40.8%) (Crepaz et al. 2018b) despite an increase use of antiretroviral medication and overall increase in sustained viral suppression over the years (Beer, Bradley, et al. 2016a; Bradley et al. 2016b). Moreover, Haitians also exhibit poor HIV care outcomes including lower levels of retention in care and viral suppression than among other Caribbean-born NHB people with HIV in South Florida (Cyrus et al. 2017a). In our study, US born individuals had higher odds of residing in geographic hotspots of poor sustained viral suppression, even after controlling for race and poverty level. Mixed results have been observed regarding US birth status and HIV care outcomes. Some studies have shown foreign-born individuals are more likely to be linked to care, retained in care, and achieve viral suppression, even though they are diagnosed at a later stage (Demeke et al. 2020; Kerani et al. 2020; Prosser, Tang, and Hall 2012). Other studies have not found any association between foreign-born and US born people with respect to retention in care or viral suppression (Breton et al. 2007; Levison et al. 2017). However, it's important to look at the racial/ethnic composition of foreign born and

geographic location of migration with regards to assessing care outcomes. A study using the Florida HIV surveillance data has shown that foreign-born Blacks and NHW had negative HIV outcomes, while foreign-born Hispanics did not show this effect (Sheehan et al. 2017a). These results are not surprising as Florida has a large population that identifies as Hispanic, especially in Miami-Dade County. Hence foreign-born Hispanics may not be exposed to language and cultural barriers that would have hindered care utilization and influence rates of sustained viral suppression (Sheehan et al. 2017a).

Those that reported acquiring HIV through heterosexual contact exhibited higher odds of residing in geographic hotspots of poor sustained viral suppression compared to clients that reported acquiring HIV through MSM contact. Prior studies that have shown that MSM are more likely to maintain a sustained viral suppression compared to heterosexuals (Marks et al. 2016a). However, it's important to note that heterosexuals includes both males and females, while MSM's are only comprised of males and are typically a group that does better than other HIV risk groups with regards to HIV care outcomes. Moreover, factors influencing HIV care outcomes might be different for males and females. Hence, further research should be conducted within this county to understand the unique factors that are influencing poor health outcomes among heterosexuals in these geographic locations. A higher mental health index (worse mental health symptoms) was also associated with higher odds of residing in the 10 ZCTAs within the North Miami area consistent with past research findings. Studies have shown the presence of mental health disorders negatively affects all steps of the HIV care continuum including, linkage to care, medication initiation and adherence, retention in care, and viral suppression (Remien et al. 2019), which ultimately affects sustained viral suppression.

In the multivariable analyses controlling for neighborhood level characteristics, Haitian had higher odds of residing in geographic hotspots of poor sustained viral suppression when compared to NHW. In South Florida, Haitians are the largest Black Caribbean immigrant group, and they typically reside in neighborhoods with low socioeconomic status (Cyrus et al. 2018). Approximately 93% of Haitians served in the RWP are not born in the US. Cyrus et al. suggest policies regarding immigration as well as the social and political environment in South Florida might influence health seeking behavior of Haitians (Cyrus et al. 2017a). Besides, favorable health outcomes were observed among Haitians living in rural areas (Cyrus et al. 2017a). In a study conducted in Palm-Beach County among immigrant Haitians, structural barriers to care, literacy, language, health beliefs, health-seeking attitude, and culture were regarded as factors affecting care outcomes for Haitians living with HIV (Potocky-Tripodi, Dodge, and Greene 2007). After controlling for individual level characteristics, neighborhood level factors, in which a higher index score indicates worse social disadvantage, were associated with residing in geographic hotspots of poor sustained viral suppression. As the value of SES disadvantage index increases, there was a higher odd of residing in geographic hotspots of poor sustained viral suppression. This is supported by prior literature that neighborhoods with low socioeconomic status were associated with poor viral suppression rates (Eberhart et al. 2015b; Rebeiro et al. 2018; Shacham et al. 2013). In particular, studies have shown that economic deprivation at the neighborhood level due to poverty and income inequality, has been a major driver of negative health outcomes (Eberhart et al. 2015b; Shacham et al. 2013). Consequently, a greater concentration of poor HIV prognosis is observed in disadvantaged neighborhoods (Ransome et al. 2016). Hence addressing socioeconomically disadvantaged neighborhood will be critical for HIV care and treatment outcomes, including ensuring

consistent viral load suppression among PWH. We also observed that the odds of residing in geographic hotspots of poor sustained viral suppression was associated with an increasing value of residential instability index. A study conducted among 10 sites across the US of women living with HIV found that living in a residentially stable neighborhood was associated with increased rate of engagement in care (Chandran et al. 2020), which ultimately affects rates of sustained viral suppression. Specifically, housing instability has been associated with lack of attaining and maintaining consistent viral suppression (Griffin et al. 2020). However, some studies have not found an association between residential instability and HIV care outcomes (Sheehan et al. 2017a; Trepka et al. 2020b). Hence, further research is needed to identify specific factors of residential instability that are associated with sustained viral suppression. Neighborhoods' racial and language composition were also associated with residing in geographic hotspots of poor sustained viral suppression. Prior studies have demonstrated that racially segregated neighborhoods are often characterized by economic and social deprivation, elevated disease burden, and health disparities (Kerr et al. 2015a; Surratt et al. 2015). Poor housing, increased policing and higher rates of incarceration, inadequate medical and societal resources, as well as racism and discrimination, profoundly impact HIV-related disparities (Ransome et al. 2016). In order to achieve health equity, dismantling structural segregation, racism, discrimination and stigma, as well as policies that negatively affect the health of marginalized populations are essential.

Our study has several limitations. Findings from this study might not be generalizable to individuals who are not in care, as this study is only focused on PWH engaged in care. The unique demographics of Miami-Dade County compared to other metropolitan areas in the US also poses a challenge of generalizability for the results.

Another limitation of our study is the use of ZIP codes to assess neighborhoods. While this administrative boundary has been used to define neighborhoods, it's important to note that ZIP codes are not designed to assess population characteristics, are not standardized, and may include multiple neighborhoods with different socioeconomic characteristics.

Conclusions

This study used data from clients enrolled in the RWP to identify geographic locations of poor sustained viral suppression. We observed the striking need in some geographic areas for comprehensive social and structural interventions to improve the health outcomes of their residents. Marginalized populations, particularly Blacks and Haitians that live in economically deprived neighborhoods, reside in hotspots of poor of sustained viral suppression. Examining the intersection of race, SES, immigration, and neighborhood factors will help elucidate individual and societal influences on health disparities. Addressing social, economic, and structural factors that hinder optimal care and render poor health outcomes are critical to ending the HIV epidemic in Miami-Dade County. Furthermore, the unique and complex demographics and geographic concentration of poor outcomes in this county should be taken into consideration when implementing policies as well as targeted social and outreach efforts to improve sustained viral suppression.

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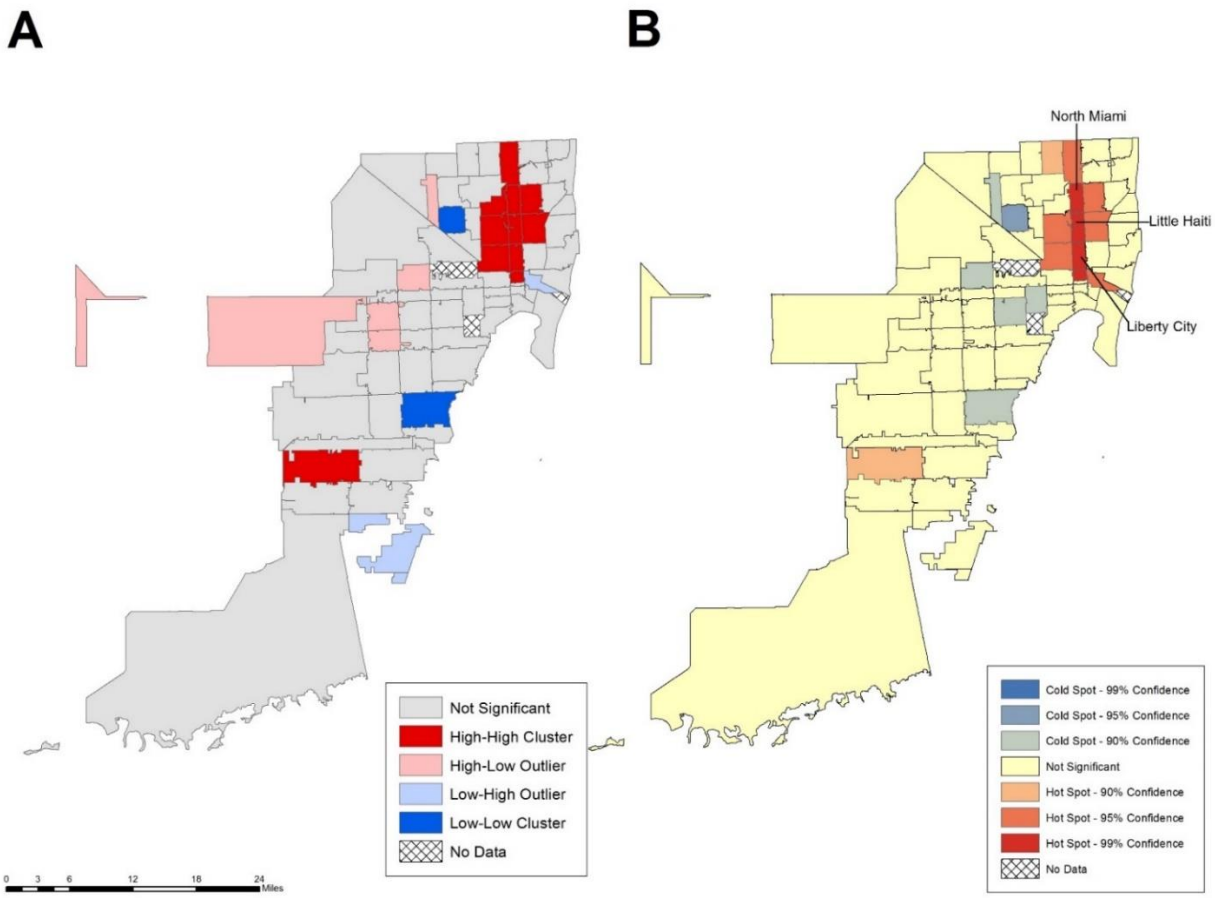

Figure 1: A) Significant clusters and outliers of Poor Sustained Viral Suppression based on Local Moran's I by ZCTAs

B) Hotspots and Cold spots of Poor Sustained Viral Suppression based on Getis Ord Gi*, in Miami-Dade County, 2017

Note: There are no spatial islands within the county. One ZCTA in the west and another one in the south are part of another ZCTA

Table 1: Descriptive characteristics of residing in geographic hotspots of poor sustained viral suppression for Ryan White HIV/AIDS program clients in Miami, Florida, 2017

Individual characteristics	**Reside in hotspots (n=2184) n %**	**Reside in other areas (n=4307) n %**	**P-value**
Race/Ethnicity			**<0.0001**
Non-Hispanic Blacks	901 (41.3)	678 (15.7)	
Hispanic	708 (32.4)	3063 (71.1)	
Haitian	465 (21.3)	245 (5.7)	
Non-Hispanic Whites	110 (5.0)	321 (7.5)	
Age (years)			**<0.0001**
18–34	410 (18.8)	1013 (23.5)	
35–49	768 (35.2)	1736 (40.3)	
≥50	1006 (46.1)	1558 (36.2)	
Gender			**<0.0001**
Males	1446 (66.2)	3542 (82.2)	
Female	738 (33.8)	765 (17.8)	
US Born			**<0.0001**
No	1196 (54.6)	3209 (74.5)	
Yes	988 (45.2)	1098 (25.5)	
Household Income in Federal Poverty Level (FPL)			**<0.0001**
≥200%	393 (17.9)	1123 (26.1)	
100%–199%	718 (32.9)	1585 (36.8)	
<100%	1073 (49.1)	1599 (37.1)	

Mode of HIV Transmission			**<0.0001**
Heterosexual	1440 (64.1)	1487 (34.5)	
Men who have sex with men	713 (32.6)	2646 (61.4)	
Injection drug use/Other	71 (3.3)	174 (4.0)	
AIDS Diagnosis			**<0.0001**
No	1148 (52.6)	2680 (62.2)	
Yes	1036 (47.4)	1627 (37.8)	
Provider's RWP Client Load[a]			**<0.0001**
1–99	668 (30.6)	1022 (23.7)	
100–199	764 (34.9)	1175 (27.3)	
≥200	651 (29.8)	1859 (43.2)	
Unknown	101 (4.6)	251 (5.8)	
	Psychosocial Indices[b]		
Mental health index			
Mean and SD	0.8; (1.09)	-0.06; (0.93)	
Median and IQR	-0.5; (-0.5; 0.8)	-0.5; (-0.5; -0.5)	**<0.0001**
Substance use index			
Mean and SD	0.04; (1.07)	-0.05; (0.89)	
Median and IQR	-0.3; (-0.3; -0.3)	-0.3; (-0.3; -0.3)	**<0.0001**
Income/SES index			
Mean and SD	0.15; (1.09)	-0.12; (0.88)	
Median and IQR	0.7; (-0.7; 0.7)	-0.7; (-0.7; 0.7)	**<0.0001**

Neighborhood Indices[b]			
SES disadvantage index			
Mean and SD	1.17; (0.55)	0.21; (0.80)	
Median and IQR	1.4; (0.7; 1.7)	0.1; (-0.2; 0.9)	**<0.0001**
Residential instability index			
Mean and SD	0.78; (0.77)	0.26; (0.12)	
Median and IQR	1.2; (0.7; 2.2)	0.1; (-0.4; 0.9)	**<0.0001**
Racial/language homogeneity index			
Mean and SD	1.20; (0.57)	-0.23; (1.02)	
Median and IQR	1.2; (0.9; 1.4)	-0.3; (-1.1; 0.5)	**<0.0001**
Homicide index			
Mean and SD	120.7; (34.63)	97.6; (47.48)	
Median and IQR	126.0; (92.8; 151.6)	91.8; (60.6; 145.4)	**<0.0001**

[a] = Number of Ryan White Program clients that a provider has
[b] = A higher index score for each index indicates increased social disadvantage/worse conditions

Table 2: Multivariable logistic regression for residing in hotspots of poor sustained viral suppression for Ryan White HIV/AIDS clients in Miami, Florida, 2017

	Crude Odds ratio		**Model 1: Individual level factors**		**Model 2: Individual + neighborhood level factors**	
	OR	**95% CI**	**aOR**	**95% CI**	**aOR**	**95% CI**
Race/Ethnicity						
NHB vs. NHW	**3.88**	**(3.06, 4.92)**	**2.83**	**(2.20, 3.65)**	0.69	(0.47, 1.02)
Hispanic vs. NHW	**0.68**	**(0.54, 0.84)**	0.77	(0.60, 1.00)	1.20	(0.80, 1.80)
Haitian vs. NHW	**5.54**	**(4.24, 7.23)**	**4.68**	**(3.43, 6.38)**	**2.22**	**(1.40, 3.52)**
Age (years)						
18–34 vs. 50+	**0.63**	**(0.55, 0.72)**	**0.82**	**(0.70, 0.97)**	**0.65**	**(0.51, 0.84)**
35–49 vs. 50+	**0.69**	**(0.61, 0.77)**	0.93	(0.81, 1.06)	**0.79**	**(0.65, 0.96)**
Gender						
Women vs. Men	**2.36**	**(2.10, 2.66)**	0.92	(0.79, 1.08)	0.94	(0.75, 1.18)
US Born						
Yes vs. No	**2.41**	**(2.17, 2.69)**	**1.26**	**(1.05, 1.51)**	1.29	(0.98, 1.69)
Household Income in FPL						
100-199% vs. ≥200%	**1.29**	**(1.12, 1.50)**	1.01	(0.86, 1.19)	0.86	(0.68, 1.09)
<100% vs. ≥200%	**1.92**	**(1.67, 2.20)**	1.18	(1.00, 1.40)	0.88	(0.68, 1.13)
Mode of HIV Transmission						
Heterosexual contact vs. MSM	**3.49**	**(3.13, 3.90)**	**1.61**	**(1.37, 1.88)**	0.93	(0.73, 1.20)
IDU +others vs. MSM	**1.51**	**1.14, 2.02)**	0.84	(0.61, 1.15)	0.63	(0.40, 1.01)
AIDS Diagnosis						
Yes vs. No	**1.49**	**(1.34, 1.65)**	1.05	(0.93, 1.18)	1.07	(0.89, 1.27)
Provider's RWP Client Load						
1–99 vs. ≥200	**1.87**	**(1.64, 2.13)**	1.11	(0.95, 1.29)	1.01	(0.81, 1.27)
100–199 vs ≥200	**1.86**	**(1.63, 2.11)**	1.15	(0.99, 1.32)	1.02	(0.82, 1.28)
Unknown vs. ≥ 200	1.15	(0.90, 1.47)	0.79	(0.60, 1.03)	0.83	(0.55, 1.27)
	Psychosocial Indices					
Mental health index	**1.16**	**(1.10, 1.22)**	**1.12**	**(1.06, 1.19)**	1.08	(0.99, 1.18)
Substance use index	**1.11**	**(1.05, 1.16)**	1.02	(0.96, 1.09)	1.05	(0.96, 1.14)
Income/SES index	**1.32**	**(1.25, 1.39)**	1.06	(0.99, 1.13)	1.04	(0.94, 1.15)

		Neighborhood Indices		
SES disadvantage index	**6.75**	**(6.11, 7.45)**	**9.13**	**(7.70, 10.81)**
Residential instability index	**1.96**	**(1.84, 2.09)**	**5.35**	**(4.44, 6.45)**
Racial/language homogeneity index	**6.25**	**(5.70, 6.86)**	**8.55**	**(7.34, 9.96)**
Homicide index	**1.01**	**(1.01, 1.01)**	1.00	(0.99, 1.00)

NHB= Non-Hispanic Black; NHW= Non- Hispanic White; FPL= Federal Poverty level; MSM= Men who have sex with men; IDU= Injection Drug Use; SES= socioeconomic; aOR= Adjusted Odds Ratio; CI= Confidence Interval

MANUSCRIPT 3

Racial/Ethnic Differences in the Associations between Sustained Viral Suppression and Travel Distance and Transportation Needs in Miami-Dade County, 2017

Abstract

Travel distance to HIV care facilities and having access to transportation may influence HIV care outcomes, especially for racial/ethnic minorities. Hence, this study examined the moderating effect of travel distance and transportation needs to HIV Medical Case Management (MCM) sites and AIDS Drug Assistance Program (ADAP) pharmacies on the association between race/ethnicity and sustained viral suppression. Data were collected from the Miami-Dade County Ryan White Program, American Community Survey, and Simply Analytics. Distance to MCM sites and ADAP pharmacies were first calculated using the Network Analyst Tool within ArcGIS. Next, we conducted multilevel logistic regression models to assess the role of having access to transportation and travel distance on the association between race/ethnicity and sustained viral suppression. Most (88.9%) of the clients traveled to MCM facilities that were farther away than the nearest facility to their residence. Racial/ethnic minorities, non-Hispanic Blacks (adjusted odds ratio:0.28; 95% confidence interval:0.10-0.76), Hispanics (0.35; 0.13-0.94), and Haitians (0.16; 0.05-0.52) had lower odds of achieving sustained viral suppression when compared to non-Hispanic Whites among clients that do not have access to transportation. Also, Haitians and NHB's had poor sustained viral suppression if they did not travel to their nearest facility and traveled longer than the median travel distance of 7.2 miles to MCM cite of choice. Racial/ethnic minority groups exhibited differences in sustained viral suppression based on traveling longer or shorter

than the median travel distance of 8.0 mile to ADAP pharmacies. Findings from this study indicates that lack of access to transportation exacerbates racial/ethnic disparities in sustained viral suppression. Hence, it's important to address transportation needs as well as understand why clients obtain care from MCM sites that are located away from their nearest facility, in order to improve health outcomes of racial/ethnic minorities.

Introduction

Access to transportation as well as proximity and geographic accessibility to care facilities and pharmacies, are important structural factors that may need to be addressed to end the HIV epidemic. Research has demonstrated that long travel distance to care can often be a barrier to health care access (Eberhart et al. 2014; Syed, Gerber, and Sharp 2013), even though some studies have found conflicting results regarding the association between travel distance to care facilities and HIV care outcomes (Ridgway et al. 2018; Terzian et al. 2018). Decreased accessibility to HIV care centers and pharmacies, longer travel distances, and travel times to care facilities may contribute to income-based, geographic, and racial/ethnic disparities in HIV care outcomes (Kimmel et al. 2018; Pham, Lewis, and Avery 2018). While most studies focused on the impact of travel distance in rural settings (Lawal et al. 2021; Moneyham et al. 2010), other studies have noted the influence of distance in urban settings (Ridgway et al. 2018; Terzian et al. 2018). A study conducted in Chicago found that persons who traveled longer to HIV care facilities had poor retention in care (Ridgway et al. 2018). Similarly, a study conducted in Washington, DC found that clients traveling more than 5 miles to HIV care facilities were less likely to be retained in care and achieve viral suppression (Terzian et al. 2018). Other studies have not found a significant association between distance to care and HIV care outcomes in urban settings (Eberhart et al. 2015a). It is likely that other factors may influence a person's choice to access care at locations further from

where they reside (Eberhart et al. 2014). These may include perceived stigma, provider-client relationship, reputation of the provider, and insurance, which could be a stronger indicator of where a person seeks care, regardless of proximity to care facilities (Eberhart et al. 2014; Terzian et al. 2018). Similarly, operating hours of care facilities and pharmacies, cost, vehicle access, public transit safety, and convenience of locations could be more of a barrier than the distance to care facility itself (Pham, Lewis, and Avery 2018; Syed, Gerber, and Sharp 2013).

Another factor affecting health care outcomes is accessibility to transportation, including vehicle access (either a personal vehicle or access to a family/friend vehicle) and mode of transportation (Syed, Gerber, and Sharp 2013). Moreover, transportation availability and getting transportation assistance are important factors that influence a patient's ability to receive and seek continuous care (Goswami et al. 2016), particularly for people living in high-poverty and high-HIV burden areas. Unmet transportation needs decreases the likelihood of accessing HIV care (Sagrestano et al. 2014), which may lead to poor engagement and health outcomes (Dandachi et al. 2019). Providing accessibility to HIV care resources by minimizing transportation-related barriers to care centers, improves HIV care outcomes,(Kimmel et al. 2018) particularly for first time clinic visits, which lead to better engagement in sustained medical care (Goswami et al. 2016). People living in economically-deprived areas often experience poor access to transportation, with lack of vehicle ownership and inadequate public transportation options (Goswami et al. 2016; Sagrestano et al. 2014). Additionally, the effects of these structural barriers often impact racial/ethnic disparities (Kimmel et al. 2018). A study conducted in 16 southern states found that non-Hispanic Blacks and Hispanics living in counties with high HIV prevalence had a longer travel time than non-Hispanic Whites in the same counties (Kimmel et al. 2018).

The most important indicator of improved health outcomes for people with HIV (PWH) is viral suppression. Examining suppression status beyond a single time point within a year supports the “U=U” (Undetectable=Untransmittable) concept that states an undetectable viral load is untransmittable (Eisinger, Dieffenbach, and Fauci 2019). Achieving sustained viral suppression, defined as having <200 copies/ml on all viral loads tests within a year (Crepaz et al. 2018a), greatly reduces the transmission risk of HIV to others (Bradley et al. 2016a; Crepaz et al. 2018a). Recent studies that have examined sustained viral suppression, demonstrate that disparities among racial/ethnic minorities exist. In particular, Blacks and Hispanics are less likely to achieve and maintain a consistently suppressed viral load throughout the year (Crepaz et al. 2018a). Hence, it is important to investigate the influence of distance to care facilities and transportation needs on sustained viral suppression and their impact on racial/ethnic disparities. To our knowledge, the association between sustained viral suppression distance to HIV care facilities and pharmacies as well as transportation needs have not been examined. We hypothesize minority’s ability to achieve sustained viral suppression will be more strongly associated with travel distance and transportation needs than for non-minorities.

Methods

Datasets

Data were collected from the Miami-Dade County Ryan White HIV/AIDS Program (RWP) in 2017. The RWP provides medical case management, antiretroviral medication through AIDS Drug Assistance Program (ADAP) pharmacies, outpatient care, specialty medical care, co-pay and premium support for clients with Affordable Care Act (ACA) [only for clients with an income above 100% of the federal poverty line], social support services, and other ancillary services for low-income, uninsured, or underinsured PWH

(Department of Health and Human Service 2021). As one of the eligible metropolitan areas to receives this federal funding, the Miami-Dade County RWP provides services to nearly 10,000 PWH every year (Partnership 2021). Clients in the RWP were included in this study if they were enrolled (receiving medical case management services, including peer education support) in the RWP prior to January 1st, 2017, ≥18 years of age, received a medical case management service, as well as had a viral load test in 2017. Clients were excluded from this study if they only received ancillary services from the program, had missing data on client assessment, viral load test, and residential zip codes, as well as had a closed cases due to financial ineligibility, relocation, or mortality. Additionally, the 2013-2017 five-year estimates for neighborhood characteristics including poverty, employment, education, income, racial/ethnic makeup, residential movements and relocation, English language aptitude, and immigration status were collected from the American Community Survey by ZIP code tabulation areas (ZCTAs), while the homicide index were collected from Simply Analytics by ZIP code. One-to-one matching of ZIP codes to ZCTAs were conducted, and the data were merged to the RWP dataset by ZIP codes.

Exposure/Predictor Variables and Outcome

Distance to medical case management (MCM) sites and ADAP pharmacies were calculated using the Network Analyst tool in ArcMap 10.8.1. Street-level data for Miami-Dade County streets were collected from Miami-Dade County Open Data Hub (Miami Dade 2021) which was used to create the streets' network distances in the Network analyst tool. A street's network distance takes into consideration the physical built environment components such as buildings, elevation, waterbodies, etc. as well as traffic elements such as one-way roads, highways, and speed limits (Eberhart et al. 2014). The Miami-Dade County ZCTA shapefile data were collected from US Census Bureau

Tiger/Line shapefiles (US Census Bureau 2017), which contains data on numerous geographic administrative boundaries and years. Due to the de-identified nature of the RWP dataset, the ZIP code of the client's residence was used to approximate their home address, where the centroid for each ZCTA was calculated. The locations for each MCM site and ADAP pharmacies were geocoded using address locator in ArcMap. Distance in miles was calculated using the closest facility function within the Network Analyst tool utilizing the client's residence ZCTA centroid as the starting point and their MCM site of choice as the destination. The distance to the nearest MCM site and nearest ADAP pharmacies were also calculated from each resident's ZCTA centroid. Travel distance variables were dichotomized into: (yes/no travel to nearest facility of care), (yes/no traveled greater than or less than the median travel distance of 7.2 miles to MCM site of choice, and yes/no traveled greater than or less than the median travel distance of 8.0 miles to nearest ADAP pharmacy). Finally, a 5-mile distance buffer radius (Terzian et al. 2018), for both the MCM sites and ADAP pharmacies were calculated using the service area function of the Network Analyst tool.

Demographic data abstracted from the RWP include age (18-34, 35-49, ≥ 50), gender (male, female), US nativity (yes, no [including US territories]), mode of HIV exposure (heterosexual contact, men who have sex with men [MSM], and injection drug use [IDU]+ others), history of AIDS diagnosis (yes, no), recipient of RWP subsidized premiums to an ACA health care (yes, no), household income in relation to the federal poverty level [FPL] (≥200%, 100%-199%, <100%), and their HIV medical provider's RWP client load. The RWP client load variable was obtained by first summing all the RWP clients in the dataset by medical provider, and classifying the values were classified into 1-99 clients, 100-199 clients, ≥200 clients). The client's variable was assigned based on their reported HIV care provider; if they did not know their HIV

provider, the value was set to unknown. Additionally, having access to transportation was extracted from the RWP dataset (yes, no; does client has access to transportation). Furthermore, three psychosocial indices (mental health index, substance use index, and income/SES index) from the RWP dataset and three neighborhood indices (socioeconomic [SES] disadvantage index, residential instability index, racial/language homogeneity index) from the American Community Survey were created using principal component analysis. Variables were chosen for the psychosocial indices based on the Andersen Behavioral Model for HIV Health Service Utilization (Christopoulos, Das, and Colfax 2011; Ulett et al. 2009a), while neighborhood indices variables were selected based on Social Disorganization theory (Browning and Cagney 2002a). A linear combination of variables' observed weights obtained from principal component analysis was calculated for each index.

The outcome variable of interest was sustained viral suppression. This was defined as having <200 copies/ml on all viral load test results in 2017. If a client had any of their viral load ≥ 200 copies/ml they were not considered suppressed. For clients who only had one suppressed viral load test that was suppressed in 2017 or only had multiple suppressed viral load tests within 3 months, their last viral load test in 2016 was additionally assessed to determine their sustained status (Dawit et al. 2021).

Statistical Analysis

All statistical analyses were performed using SAS 9.4. Summary statistics using Chi-squared for categorical variables and Wilcoxon rank-sum test for continuous variables were computed to describe the distribution of the clients in the RWP by travel distance variables (travel distance to the nearest facility of care, median travel distances to clients MCM site of choice and median travel distance to nearest ADAP pharmacy). This was followed by four separate multilevel logistic regression models to examine the

moderating role of travel distance variables as well as having access to transportation on the association between race/ethnicity and sustained viral suppression. To determine if a multilevel model was needed, we first ran an unconditional model to measure the intraclass correlation (ICC) using a random intercept model with ZIP code random effects. Next, we ran a model which included only individual-level variables (demographic, travel distance variables, having access to transportation, and psychosocial indices). The third model included the individual-level variables from the second model and neighborhood-level variables (three indices: socioeconomic [SES] disadvantage index, residential instability index, racial/language homogeneity index) and homicide index. Lastly, the final model included all the variables from the third model in addition to interaction terms between the travel distance variables and race/ethnicity as well as having access to transportation and race/ethnicity. These models were analyzed separately for MCM site and ADAP pharmacies. Additionally, maps of Miami-Dade County illustrating a 5-mile service buffer radius was generated for MCM sites and ADAP pharmacies using ArcMap 10.8.1.

Results

There was a total of 6180 clients in the RWP that were included in this analysis. Race/ethnicity, US nativity, physician's RWP client case volume, having access to transportation, and SES disadvantage index were significantly associated with travel distance to nearest facility of care (Table 1). Most (88.9%) clients sought care at a MCM site that was not the one closest to their residents. Table 1 also shows the median travel distance to client's MCM site and median distance to client's nearest ADAP pharmacy. The median travel distance for all clients to the MCM sites of their choice and nearest ADAP pharmacy was 7.2 miles and 8.0 miles, respectively. Given the median travel distance to MCM site of 7.2 miles and median travel distance to nearest ADAP

pharmacy of 8.0 miles, Haitians, foreign born, clients enrolled in an ACA health plan, and clients who have access to transportation traveled the longest over these thresholds. Adults 18-34 years old, males, those with household income >200% of the FPL, those with an MSM primary modes of HIV exposure, those without an AIDS diagnosis, clients who see physicians who have a case volume of ≥200 clients, and those who achieved sustained viral suppression traveled the farthest to their MCM site. Conversely, adults ≥50 years of age, females, those with household income between 100%-199% of the FPL, those with a heterosexual primary mode of HIV exposure, and clients who see physicians who have a case volume of <99 clients traveled the farthest to their nearest ADAP pharmacy. Distribution of the service providers and the 5 mile-distance buffer radii from the MCM site and ADAP pharmacies are displayed in Figure 1.

Results for the multilevel logistic regression models are shown in Table 2 for MCM site. The unconditional random intercept model from model 1 indicated an ICC of 0.04, indicating that 4% of the variation in achieving sustained viral suppression is due to characteristics at the neighborhood level. While the value of the ICC was small, it was appropriate to study the effects of neighborhood using a multilevel model, as studies have shown that even an ICC of 5% shows important geographic variations (Burke-Miller et al. 2016). When looking at the individual level variables only in the model, we see that NHB and Haitians vs. NHW, 18-49 vs ≥50, household incomes <100% FPL vs ≥200% FPL, having an AIDS diagnosis, unknown vs. ≥200 provider's RWP client load, not having access to transportation, and having higher psychosocial indices value (poor mental health, high substance use, and low income/SES) had lower odds of achieving sustained viral suppression (Table 2). Clients enrolled in an ACA health plan had higher odds of sustained viral suppression than those not in ACA (Table 2). None of the neighborhood indices were significantly associated with sustained viral suppression in

Model 3. In Model 4, three separate interactions were included. The overall moderating effect of travel distance variables on the association between race/ethnicity and sustained viral suppression was not significant. However, we observe significant results for race/ethnicity conditional on travel distance variables and access to transportation. Haitians had lower odds of achieving sustained viral suppression compared to NHW among those who have access to transportation (adjusted odds ratio [aOR]: 0.53; 95% confidence interval [CI]:0.35-0.80). Among clients who do not have access to transportation NHB (0.28; 0.10-0.76), Hispanics (0.35; 0.13-0.94), and Haitians (0.16; 0.05-0.52) had lower odds of achieving sustained viral suppression when compared to NHW. Non-Hispanic Blacks (0.66; 0.46-0.94) and Haitians (0.46: 0.31-0.70) had lower odds of sustained viral suppression compared to NHW among clients that did not travel to their nearest MCM site. We did not observe a statistically significant racial/ethnic disparities among clients who traveled to their nearest MCM. Among clients who travel more than the median distance of 7.2 miles to their MCM, NHB and Haitians had also exhibited lower odds of sustained viral suppression (0.55; 0.36-0.84) and (0.39; 0.24-0.66) respectively when compared to NHW. No racial/ethnic disparities were observed among clients that traveled less than or equal to the median distance of 7.2 miles to their MCM site.

Table 3 shows the results of the multilevel model for ADAP pharmacies analysis. Similar results to that of the MCM site in Table 2 were observed for Models 1-3 for the ADAP pharmacies models. In Model 4, we observed some significant interactions between race/ethnicity and sustained viral suppression within each travel distance variable and access to transportation variable. The odds of achieving sustained viral suppression were lower for Haitians vs. NHW (0.53; 0.35-0.79) among those that have access to transportation. While among clients that do not have access to transportation

all racial/ethnic minority groups had lower odds of sustained viral suppression; NHB (0.28; 0.10-0.77), Hispanics (0.36; 0.13-.95), and Haitians (0.17; 0.05-0.54) when compared to NHWs in the same transport predicament. Additionally, among those that traveled more than 8.0 miles (median) to their nearest ADAP pharmacy, NHB compared to NHWs had lower odds of sustained viral suppression (0.48: 0.29-0.79). Lastly, Haitians (0.50; 0.30-0.80) had lower odds of sustained viral suppression when compared to NHW among clients who traveled less than or equal to the median distance of 8.0 miles to their nearest ADAP pharmacy.

Discussion

This study sought to investigate the association between race/ethnicity and sustained viral suppression and the moderating effect of travel distance and transportation needs in this association. Our analysis suggests four primary findings. First, our study noted that the majority of clients (88.9%) used MCM facilities that were farther than their nearest facility to seek care. Second, racial/ethnic minorities (Hispanics, Haitians, and NHBs) had lower odds of sustained viral suppression when compared to NHW among clients who did not have access to transportation. Third, NHB's and Haitians had lower odds of sustained viral suppression compared to NHW if they did not use their nearest MCM site and if they traveled farther than the median distance of 7.2 miles to seek care. Finally, Haitians had also exhibited lower odds of sustained viral suppression when compared to NHW among clients that traveled less than or equal to the median distance of 8.0 miles to their nearest ADAP pharmacy, while NHB had poor outcomes when compared to NHW among clients that traveled more than the median 8.0 miles to their nearest ADAP pharmacy to receive their medication.

In our study, RWP clients traveled farther than their nearest care facility to receive care. We observed that clients that have achieved sustained viral suppression

traveled slightly farther distance, above the median threshold of 7.2 miles to their MCM site. Most of the RWP facilities are located in the northeastern part of the county, as noted in figure 1. Such concentration of service providers in the northeastern part of Miami-Dade County is justified based on the low socioeconomic status of the area and presence of high risky behaviors such as substance (Ganapati et al. 2010). However, there has been a recent westward spread of HIV/AIDS in the county where there are no service provide (Ganapati et al. 2010). Hence, allocation of resources, including RWP subcontracted facilities in the western part of county might alleviate some of the longer distance traveled by clients. However, previous studies have also found that PWH seek care from facilities that are farther than the closest one from their residence (Eberhart et al. 2014; Terzian et al. 2018). These studies suggest that PWH might travel far due to needing facilities that provide a variety of ancillary services, seeking care at multiple facilities for other comorbid conditions, provider preferences, and fear of stigma or disclosure of HIV status (Eberhart et al. 2014; Moneyham et al. 2010; Terzian et al. 2018). Additionally, there are only two ADAP pharmacies located in Miami-Dade County, where accessibility of these pharmacies will be influenced by hours of operation, delivery service options, and convenience of location (Pham, Lewis, and Avery 2018). Further studies, particularly qualitative studies, need to be conducted to determine factors that are influencing PWH to seek care away from their nearest facility.

Among clients that do not have access to transportation, all racial/ethnic minorities had lower odds of sustained viral suppression when compared to NHWs. Conversely, Hispanics and NHB that have access to transportation did not differ from NHW in sustained viral suppression. However, Haitians exhibited lower odds of sustained viral suppression even among clients with access to transportation when compared to NHW. Racial/ethnic minorities face various challenges including residing in

low socioeconomic neighborhoods (Kerr et al. 2015b), which can impact their health. A study has shown that transportation accessibility including vehicle ownership and access to permanent and consistent means of transportation, particularly in low socioeconomic neighborhoods was significantly associated with retention in care and viral suppression, respectively (Goswami et al. 2016). However having inadequate access to transportation combined with longer distance to care facilities is a barrier to care (Kempf et al. 2010). Hence, lacking access to transportation might be influencing racial/ethnic minorities from achieving a consistently suppressed viral load.

Particularly Haitians and NHBs in our study had lower odds of achieving sustained viral suppression among different travel distance variables (travel farther away from nearest MCM site and travel beyond the median travel distances of 7.2 miles to clients MCM site of choice) when compared to NHWs. We did not observe these differences for NHB and Haitian clients that traveled to their nearest MCM site and those that traveled less than the median travel distance threshold. In addition to transportation needs, Haitian immigrants and Haitian Americans face numerous challenges, including stigma and fear of disclosure to family, friends, and society, low socioeconomic status, legal and sociopolitical climate, cultural barriers and belief systems, low education and literacy levels, and language barriers, which serve as barriers to achieving optimal HIV care outcomes (Barsky and Albertini 2006; Potocky-Tripodi, Dodge, and Greene 2007). Thus, there might be unmeasured confounding from factors such as stigma and fear of disclosure that is contributing to traveling longer distance to MCM sites. Also, in a study that was conducted among Caribbean born immigrants in Florida, Haitians were less likely to be retained in care and achieve viral suppression (Cyrus et al. 2017b). Studies have also shown that NHBs carry a higher disease burden and are less likely to achieve viral suppression and sustained viral suppression (Crepaz et al. 2018a; Nwangwu-Ike et

al. 2018). Hence, traveling longer distance to care facilities might be a contributing factor to the poor health outcomes of NHBs and Haitians.

Additionally, difference in sustained viral suppression were observed for NHB's and Haitians accessing ADAP pharmacies. We observed that NHBs exhibited poor sustained viral suppression when traveling longer than the median travel distance of 8.0 miles to their nearest ADAP pharmacy, while Haitians had lower odds of sustained viral suppression if they traveled 8.0 miles or less to their nearest ADAP pharmacy. Factors influencing poor sustained viral suppression for NHB's traveling longer distance might include transportation cost (Wohl et al. 2017) and accessibility to pharmacies (hours of operation, convenience and safety of pharmacy location) (Pham, Lewis, and Avery 2018), which affects medication adherence and ultimately sustained viral suppression. A qualitative study conducted among clients from RWP clinics in Philadelphia found that fear of HIV status disclosure in care facilities including pharmacies was a barrier for PWH (Yehia et al. 2015). Fear of stigma from HIV status disclosure might serve as a barrier for Haitians accessing medication in an ADAP pharmacy that is close to their place of residence. Moreover, ADAP assess clients rectification every six-months to determine eligibility in the program, which may lead to interruption of service and serve as a barrier medication adherence (Wohl et al. 2017). It is important to note that in Miami-Dade County, there were only two ADAP pharmacy locations in 2017. However, ADAP pharmacy delivery service has improved over the years in the county. In 2017, uninsured RWP clients were only able to pick up their medication from the West Perrine facility, which is in the Homestead area. Nevertheless, since 2019 clients are now being served by CVS Specialty Pharmacy that provides delivery options including delivery at home, picking up at a retail CVS store through the CVS Connect Program, or picking up at the West Perrine location. Even though there is limited research regarding the

influence of proximity of pharmacy on HIV care outcomes, some studies have shown home delivery service rather than traditional pharmacy delivery systems serve as facilitators to medication adherence (Pham, Lewis, and Avery 2018; Sagrestano et al. 2014).

This study has several limitations. First, our analysis utilized the centroid of the client's ZCTA of residence to measure distance to care facilities, which limits our precision for our distance variables as not all clients live in or near the centroid of a ZCTA. Also using centroid distances likely has measurement errors and misclassification. Clients in the same ZCTA that go to the same location also have the same travel distance regardless of race/ethnicity. Hence it has reduced the variation of travel distance compared to the actual distance. However, due to the sensitivity of the data, we could not use client's residential address. Second, we only included travel from a residential ZCTA to care facilities and did not consider that client's origin of transportation might be from other locations including workplaces. Third, since we did not have data to identify which of the two ADAP pharmacies were being utilized by RWP clients, we calculated distance to the nearest ADAP pharmacy from each of the ZCTA's centroid. This might not accurately reflect the distance which clients traveled to access their medication in 2017. Lastly, our distance calculation did not factor in the use of public transportation routes or actual mode of transportation used by clients, which might increase travel distance and time to MCM sites and ADAP pharmacies.

Conclusion

Having a reliable and consistent transportation plays a crucial role in accessing health care and is an important facilitator to achieve optimal health outcomes. This study identified that RWP clients who did not have access to transportation had poor sustained viral suppression rates and these differences were magnified for racial/ethnic minorities.

Additionally, we found that longer travel distance disproportionally affected minorities, particularly Haitians and NHB's. Addressing these transportation and distance barriers to care by examining the feasibility of telehealth might alleviate the challenges faced by racial/ethnic minorities and minimize disparities. Furthermore, we observed clients in general chose a facility that was not closest to their place of residency, consistent with prior studies, indicating that other factors besides travel distance might be important indicators of where clients access care. Hence, future studies should examine these factors to work towards ending the HIV epidemic.

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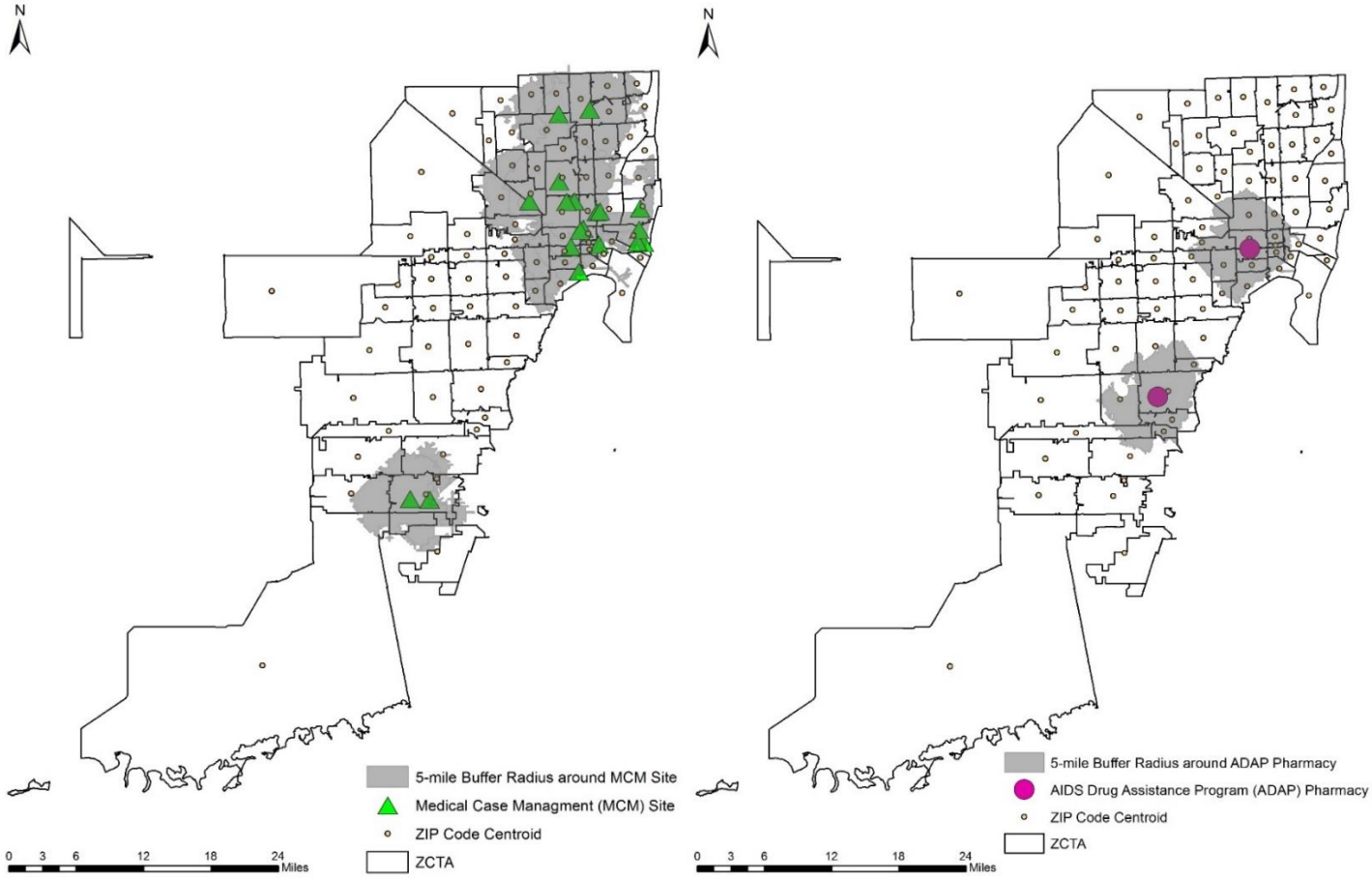

Figure 1: Left: Area within 5-mile travel distance from Medical Case Management (MCM) sites in Miami-Dade County, Florida
Right: Area within 5-mile travel distance from AIDS Drug Assistance Program (ADAP) pharmacies in Miami-Dade County, Florida

Table 1: Characteristics of RWP clients by travel distance variables in Miami Dade County, Florida, 2017

Characteristics	Travel to nearest MCM		P-value	Median travel distance to MCM of choice in miles (Median, IQR)	Median travel distance to nearest ADAP in miles (Median, IQR)
	Yes	No			
Total	687 (11.1)	5493 (88.9)		7.2 (0.35-35.6)	8.0 (0.54-31.6)
Race/Ethnicity			**<0.0001**		
NHB	205 (13.8)	1281 (86.2)		5.47 (3.29-9.40)	7.48 (3.85-11.28)
Hispanic	372 (10.3)	3241 (89.7)		8.38 (4.08-13.2)	7.48 (3.26-10.97)
Haitian	44 (6.5)	638 (93.6)		8.56 (5.47-11.49)	11.28 (8.26-13.29)
NHW	66 (16.5)	333 (83.5)		5.82 (3.29-9.74)	8.02 (6.85-10.97)
Age			0.1247		
18–34	163 (12.2)	1172 (87.8)		7.35 (3.83-12.04)	8.02 (4.39-11.28)
35–49	275 (11.5)	2121 (88.5)		7.21 (3.67-11.77)	8.02 (4.39-11.28)
≥50	249 (10.2)	2200 (89.8)		7.07 (3.67-11.83)	8.02 (4.66-11.28)
Gender			0.5708		
Males	521 (11.0)	4219 (89.0)		7.21 (3.68-12.04)	7.48 (4.39-11.16)
Female	166 (11.5)	1274 (88.5)		6.64 (3.67-11.36)	8.26 (6.05-11.28)
US Born			**<0.0001**		
No	400 (9.5)	3824 (90.5)		8.38 (4.53-12.51)	8.02 (4.39-11.28)
Yes	287 (14.7)	1669 (85.3)		5.61 (3.38- 9.76)	7.48 (5.38-10.99)
Household Income (FPL)			0.2200		
>200%	177 (12.3)	1263 (87.7)		7.66 (4.12-12.24)	8.14 (4.53-11.28)
100%–199%	244 (11.1)	1960 (88.9)		7.21 (3.95-12.17)	8.02 (5.38-11.28)
<100%	266 (10.5)	2270 (89.5)		6.78 (3.61-11.35)	7.48 (4.39-11.28)
Mode of HIV Transmission			0.1928		
Heterosexual	287 (10.4)	2476 (89.6)		6.78 (3.64-11.34)	8.26 (5.66-11.28)
MSM	370 (11.6)	2821 (88.4)		7.44 (3.83-12.41)	7.48 (4.39-10.97)
IDU & Other	30 (13.3)	196 (86.7)		7.39 (4.15-12.07)	8.02 (4.39-11.28)
History of AIDS Diagnosis			0.5883		

No	411 (11.3)	3227 (88.7)		7.21 (3.86-12.17)	8.02 (4.66-11.28)
Yes	276 (10.9)	2266 (89.1)		7.03 (3.63-11.68)	8.02 (4.66-11.28)
Number of Clients that Physician Has			**0.0044**		
1–99	152 (9.4)	1459 (90.6)		7.23 (4.60-12.17)	8.69 (6.05-11.28)
100–199	222 (12.1)	1614 (87.9)		6.47 (3.61-11.28)	8.02 (5.66-11.28)
≥200	261 (10.9)	2137 (89.1)		7.56 (3.67-12.20)	7.48 (3.26-10.99)
Unknown Physician	52 (15.5)	283 (84.5)		6.60 (3.48-11.35)	8.02 (4.39-11.28)
Enrolled in ACA Health Care Plan			0.7023		
No	579 (11.1)	4660 (89.0)		7.07 (3.67-11.77)	8.02 (4.66-11.28)
Yes	108 (11.5)	833 (88.5)		7.68 (4.69-12.47)	8.26 (4.39-11.28)
Access to Transportation			**<0.0001**		
Yes	593 (10.5)	5044 (89.5)		7.21 (3.71-11.93)	8.02 (4.66-11.28)
No	94 (17.3)	449 (82.7)		6.94 (3.43-11.22)	7.48 (3.46-10.97)
Sustained Viral Suppression			0.3239		
No	119 (10.3)	1037 (89.7)		6.26 (3.58-10.59)	8.02 (4.66-11.28)
Yes	568 (11.3)	4456 (88.7)		7.33 (3.83-12.11)	8.02 (4.66-11.28)
Psychosocial Indices [a]					
Mental health index					
Mean and SD	0.05; (1.04)	-0.01; (0.99)			
Median and IQR	-0.49; (-0.48:0.88)	-0.48; (-0.48: -0.48)	0.0692		
Substance use index					
Mean and SD	0.02; (1.06)	-0.003; (0.99)			
Median and IQR	-0.25; (-0.25: -0.25)	-0.25); (-0.25: -0.25)	0.9795		
Income/SES index					
Mean and SD	-0.03; (0.99)	0.003; (1.00)			
Median and IQR	-0.67; (-0.67: 0.70)	-0.67; (-0.67: 0.70)	0.3185		
Neighborhood Indices [a]					
SES disadvantage index					
Mean and SD	0.30; (0.80)	0.57; (0.86)			
Median and IQR	0.29; (-0.35: 0.79)	0.76; (-0.13: 1.37)	**<0.0001**		
Residential instability index					

Mean and SD	0.45; (0.87)	0.43; (0.90)	
Median and IQR	0.51; (-0.32: 1.36)	0.33; (-0.29: 1.09)	0.9584
Racial/language homogeneity index			
Mean and SD	0.26; (0.95)	0.24; (1.15)	
Median and IQR	0.28; (-0.28: 0.98)	0.28; (-0.52: 1.18)	0.8347
Homicide index			
Mean and SD	104.37; (45.05)	105.43 (44.88)	
Median and IQR	101.8; (65.6: 151.6)	101.8; (68.0: 148.2)	0.2847

NHB: Non-Hispanic Black; NHW: Non-Hispanic White; MSM: Men who have sex with men; FPL: Federal Poverty Level; IDU: Injection drug use; ACA: Affordable Care Act; SES: socioeconomic; MCM: Medical case management; ADAP: AIDS Drug Assistance Program

[a] = A higher index score for each index indicates increased social disadvantage/worse conditions

Table 2: Multilevel mixed effects models for sustained viral suppression for Ryan White HIV/AIDS Program Clients by Race/ethnicity and Travel distance variables to Medical Case Management Sites (MCM) in Miami-Dade County, Florida, 2017

	Model 1: Crude/ unadjusted			**Model 2: Individual variables**			**Model 3: Individual+ neighborhood**			**Model 4: Access to transportation* race/ethnicity**			**Model 4: Nearest MCM* race/ethnicity**			**Model 4: Median distance to MCM* race/ethnicity**		
	OR	**95% CI**		**OR**	**95% CI**		**OR**	**95% CI**		**OR**	**95% CI**		**OR**	**95% CI**		**OR**	**95% CI**	
Race/ethnicity																		
NHB vs. NHW	**0.50**	**0.37**	**0.68**	**0.60**	**0.43**	**0.83**	0.63	0.45	0.88	**0.44**	**0.26**	**0.76**	**0.55**	**0.34**	**0.90**	**0.64**	**0.44**	**0.92**
Hispanic vs. NHW	1.15	0.86	1.54	0.92	0.66	1.29	0.89	0.63	1.25	0.59	0.34	1.01	0.75	0.46	1.23	0.91	0.63	1.30
Haitian vs. NHW	**0.53**	**0.38**	**0.75**	**0.44**	**0.30**	**0.64**	**0.47**	**0.32**	**0.70**	**0.29**	**0.16**	**0.55**	**0.59**	**0.31**	**1.12**	**0.48**	**0.32**	**0.73**
Age																		
18–34 vs. 50+	**0.50**	**0.42**	**0.59**	**0.37**	**0.31**	**0.45**	**0.38**	**0.31**	**0.46**	**0.38**	**0.31**	**0.46**	**0.37**	**0.31**	**0.45**	**0.38**	**0.31**	**0.46**
35–49 vs. 50+	**0.69**	**0.59**	**0.81**	**0.55**	**0.47**	**0.65**	**0.55**	**0.47**	**0.65**	**0.55**	**0.47**	**0.65**	**0.55**	**0.47**	**0.65**	**0.55**	**0.47**	**0.65**
Gender																		
Women vs. Men	**0.84**	**0.72**	**0.97**	1.11	0.92	1.34	1.11	0.92	1.34	1.11	0.92	1.34	1.12	0.93	1.35	1.11	0.92	1.34
US Born																		
Yes vs. No	**0.57**	**0.49**	**0.65**	0.85	0.68	1.05	0.85	0.69	1.05	0.85	0.68	1.05	0.84	0.68	1.05	0.85	0.68	1.05
Household Income in FPL																		
100-199% vs. ≥200%	**0.68**	**0.55**	**0.83**	**0.77**	**0.62**	**0.95**	**0.77**	**0.62**	**0.95**	**0.77**	**0.62**	**0.95**	**0.77**	**0.62**	**0.95**	**0.76**	**0.62**	**0.95**
<100% vs. ≥200%	**0.35**	**0.29**	**0.42**	**0.54**	**0.44**	**0.67**	**0.54**	**0.44**	**0.67**	**0.54**	**0.44**	**0.67**	**0.54**	**0.44**	**0.67**	**0.54**	**0.44**	**0.67**
Mode of HIV Transmission																		
Heterosexual vs. MSM	**0.71**	**0.61**	**0.82**	0.86	0.71	1.05	0.87	0.72	1.06	0.87	0.72	1.06	0.87	0.72	1.06	0.87	0.72	1.06
IDU vs. MSM	**0.51**	**0.37**	**0.70**	0.78	0.55	1.10	0.77	0.54	1.09	0.76	0.54	1.08	0.77	0.54	1.09	0.77	0.54	1.09

History of AIDS Diagnosis																		
Yes vs. No	**0.59**	**0.52**	**0.67**	**0.55**	**0.48**	**0.63**	**0.55**	**0.47**	**0.63**	**0.55**	**0.48**	**0.63**	**0.55**	**0.47**	**0.63**	**0.55**	**0.48**	**0.63**
Number of Clients that Physician Has																		
1–99 vs. ≥200	**0.74**	**0.63**	**0.88**	0.87	0.73	1.04	0.88	0.73	1.05	0.88	0.73	1.05	0.88	0.73	1.05	0.87	0.73	1.05
100–199 vs ≥200	**0.77**	**0.66**	**0.91**	0.93	0.78	1.10	0.93	0.78	1.11	0.93	0.78	1.11	0.93	0.78	1.11	0.93	0.78	1.11
Unknown vs. ≥200	**0.48**	**0.36**	**0.62**	**0.64**	**0.48**	**0.86**	**0.63**	**0.47**	**0.84**	**0.63**	**0.47**	**0.84**	**0.63**	**0.47**	**0.85**	**0.63**	**0.47**	**0.85**
Enrolled in ACA Health Care Plan																		
Yes vs. No	**2.21**	**1.76**	**2.77**	**1.37**	**1.08**	**1.74**	**1.37**	**1.08**	**1.75**	**1.37**	**1.08**	**1.74**	**1.37**	**1.08**	**1.75**	**1.37**	**1.08**	**1.75**
Access to Transportation																		
No vs. Yes	**0.64**	**0.52**	**0.79**	**0.71**	**0.57**	**0.89**	**0.71**	**0.57**	**0.90**	0.85	0.61	1.17	**0.70**	**0.56**	**0.88**	**0.72**	**0.57**	**0.90**
Travel to Nearest MCM																		
No vs. Yes	0.97	0.78	1.20	0.80	0.64	1.01	0.82	0.65	1.04	0.82	0.65	1.03	**0.66**	**0.47**	**0.92**	0.83	0.66	1.04
Travel Distance to MCM (median distance=7.2 miles)																		
>7.2 miles vs. ≤7.2 miles	**1.24**	**1.06**	**1.44**	**1.16**	**1.01**	**1.35**	1.16	0.97	1.38	1.16	0.97	1.38	1.16	0.97	1.39	1.10	0.88	1.36
Psychosocial Indices [a]																		
Mental health index	**0.76**	**0.72**	**0.81**	**0.85**	**0.80**	**0.91**	**0.85**	**0.80**	**0.91**	**0.85**	**0.80**	**0.91**	**0.85**	**0.80**	**0.91**	**0.85**	**0.80**	**0.91**
Substance use index	**0.78**	**0.74**	**0.83**	**0.89**	**0.84**	**0.95**	**0.89**	**0.84**	**0.95**	**0.89**	**0.84**	**0.95**	**0.89**	**0.84**	**0.95**	**0.89**	**0.84**	**0.95**
Income/SES index	**0.69**	**0.66**	**0.74**	**0.84**	**0.78**	**0.90**	**0.84**	**0.78**	**0.90**	**0.84**	**0.78**	**0.90**	**0.84**	**0.78**	**0.90**	**0.84**	**0.78**	**0.90**
Neighborhood Indices [a]																		
SES disadvantage index	**0.80**	**0.71**	**0.91**				0.97	0.87	1.08	0.98	0.88	1.09	0.98	0.87	1.09	0.98	0.88	1.09
Residential instability index	**0.84**	**0.74**	**0.96**				0.94	0.82	1.07	0.94	0.82	1.07	0.93	0.81	1.07	0.93	0.81	1.07

Racial/ language homogeneity index	**0.77**	**0.71**	**0.84**	0.94	0.86	1.02	0.94	0.86	1.02	0.94	0.86	1.02	0.94	0.86	1.02
Homicide index	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Interactions for subgroups																
Access to Transport (Yes)																
(NHB vs. NHW)							0.70	0.50	1.00							
(Hispanics vs. NHW)							1.01	0.71	1.43							
(Haitian vs. NHW)							**0.53**	**0.35**	**0.80**							
Access to Transport (No)																
(NHB vs. NHW)							**0.28**	**0.10**	**0.76**							
(Hispanics vs. NHW)							**0.35**	**0.13**	**0.94**							
(Haitian vs. NHW)							**0.16**	**0.05**	**0.52**							
Travel to Nearest MCM (Yes)																
(NHB vs. NHW)										0.46	0.19	1.12				
(Hispanics vs. NHW)										0.60	0.25	1.47				
(Haitian vs. NHW)										0.75	0.23	2.47				
Travel to Nearest MCM (No)																
(NHB vs. NHW)										**0.66**	**0.46**	**0.94**				
(Hispanics vs. NHW)										0.94	0.66	1.34				
(Haitian vs. NHW)										**0.46**	**0.31**	**0.70**				
Distance to MCM (median distance >7.2 Miles)																
(NHB vs. NHW)													**0.55**	**0.36**	**0.84**	
(Hispanics. NHW)													0.79	0.52	1.22	
(Haitian vs. NHW)													**0.39**	**0.24**	**0.66**	
Distance to MCM (median distance ≤7.2 Miles)																
(NHB vs. NHW)													0.77	0.46	1.27	
(Hispanics vs. NHW)													1.06	0.65	1.73	
(Haitian vs. NHW)													0.58	0.34	1.00	

NHB: Non-Hispanic Black; NHW: Non-Hispanic White; MSM: Men who have sex with men; FPL: Federal Poverty Level; IDU: Injection drug use; ACA: Affordable Care Act; SES: socioeconomic; MCM: Medical case management; ADAP: AIDS Drug Assistance Program

[a] = A higher index score for each index indicates increased social disadvantage/worse conditions

Table 3: Multilevel mixed effects models for sustained viral suppression for Ryan White HIV/AIDS Program Clients by Race/ethnicity and travel distance variables to AIDS Drug Assistance Program (ADAP) in Miami-Dade County, Florida, 2017

	Model 1: Crude/unadjusted			**Model 2: Individual**			**Model 3: Individual+ neighborhood**			**Model 4: Access to transportation* race/ethnicity**			**Model 4: ADAP*race/ethnicity**		
	OR	**95% CI**		**OR**	**95% CI**		**OR**	**95% CI**		**OR**	**95% CI**		**OR**	**95% CI**	
Race/Ethnicity															
NHB vs. NHW	**0.50**	**0.37**	**0.68**	**0.60**	**0.44**	**0.84**	**0.63**	**0.45**	**0.88**	**0.44**	**0.26**	**0.76**	**0.64**	**0.46**	**0.90**
Hispanic vs. NHW	1.15	0.86	1.54	0.94	0.67	1.31	0.89	0.63	1.25	0.60	0.35	1.02	0.90	0.64	1.26
Haitian vs. NHW	**0.53**	**0.38**	**0.75**	**0.44**	**0.30**	**0.66**	**0.47**	**0.31**	**0.69**	**0.30**	**0.16**	**0.56**	**0.51**	**0.34**	**0.77**
Age															
18–34 vs. 50+	**0.50**	**0.42**	**0.59**	**0.38**	**0.31**	**0.46**	**0.38**	**0.31**	**0.46**	**0.38**	**0.31**	**0.46**	**0.37**	**0.31**	**0.46**
35–49 vs. 50+	**0.69**	**0.59**	**0.81**	**0.55**	**0.47**	**0.65**	**0.55**	**0.47**	**0.65**	**0.56**	**0.47**	**0.65**	**0.55**	**0.47**	**0.65**
Gender															
Women vs. Men	**0.84**	**0.72**	**0.97**	1.12	0.93	1.35	1.12	0.93	1.34	1.12	0.93	1.34	1.12	0.93	1.35
US born															
Yes vs. No	**0.57**	**0.49**	**0.65**	0.85	0.69	1.05	0.85	0.69	1.05	0.85	0.68	1.05	0.86	0.69	1.06
Household Income FPL															
100-199% vs. ≥200%	**0.68**	**0.55**	**0.83**	**0.76**	**0.62**	**0.95**	**0.76**	**0.62**	**0.94**	**0.76**	**0.62**	**0.95**	**0.76**	**0.62**	**0.94**
<100% vs. ≥200%	**0.35**	**0.29**	**0.42**	**0.54**	**0.43**	**0.67**	**0.54**	**0.44**	**0.67**	**0.54**	**0.44**	**0.67**	**0.54**	**0.43**	**0.67**
Mode of HIV Transmission															
Heterosexual vs. MSM	**0.71**	**0.61**	**0.82**	0.86	0.71	1.04	0.87	0.72	1.06	0.87	0.71	1.06	0.87	0.72	1.06
IDU vs. MSM	**0.51**	**0.37**	**0.70**	0.78	0.55	1.11	0.77	0.54	1.09	0.76	0.54	1.08	0.76	0.54	1.08
History of AIDS Diagnosis															
Yes vs. No	**0.59**	**0.52**	**0.67**	**0.55**	**0.48**	**0.64**	**0.55**	**0.48**	**0.64**	**0.55**	**0.48**	**0.64**	**0.55**	**0.48**	**0.64**
Number of Clients that Physician Has															
1–99 vs. ≥200	**0.74**	**0.63**	**0.88**	0.87	0.73	1.04	0.88	0.73	1.05	0.88	0.73	1.05	0.88	0.73	1.05
100–199 vs ≥200	**0.77**	**0.66**	**0.91**	0.92	0.77	1.10	0.93	0.78	1.11	0.93	0.78	1.10	0.93	0.78	1.11
Unknown vs. ≥200	**0.48**	**0.36**	**0.62**	**0.64**	**0.48**	**0.86**	**0.63**	**0.47**	**0.85**	**0.63**	**0.47**	**0.85**	**0.63**	**0.47**	**0.84**

Enrolled in ACA health care plan															
Yes vs. No	**2.21**	**1.76**	**2.77**	**1.38**	**1.08**	**1.75**	**1.37**	**1.08**	**1.74**	**1.36**	**1.07**	**1.73**	**1.37**	**1.08**	**1.74**
Access to Transportation															
No vs. Yes	**0.64**	**0.52**	**0.79**	**0.72**	**0.57**	**0.90**	**0.72**	**0.58**	**0.91**	0.86	0.62	1.19	**0.73**	**0.58**	**0.91**
Travel Distance to nearest ADAP (median distance= 8.0 miles)															
>8.0 miles vs. ≤8.0miles	0.93	0.73	1.18	0.99	0.85	1.16	0.98	0.81	1.18	0.98	0.81	1.18	0.84	0.66	1.06
Psychosocial Indices [a]															
Mental health index	**0.76**	**0.72**	**0.81**	**0.85**	**0.80**	**0.90**	**0.85**	**0.80**	**0.91**	**0.85**	**0.80**	**0.91**	**0.85**	**0.80**	**0.91**
Substance use index	**0.78**	**0.74**	**0.83**	**0.89**	**0.84**	**0.95**	**0.89**	**0.84**	**0.95**	**0.89**	**0.84**	**0.94**	**0.89**	**0.84**	**0.95**
Income/SES index	**0.69**	**0.66**	**0.74**	**0.84**	**0.78**	**0.90**	**0.84**	**0.78**	**0.90**	**0.84**	**0.78**	**0.90**	**0.84**	**0.78**	**0.90**
Neighborhood Indices [a]															
SES disadvantage index	**0.80**	**0.71**	**0.91**				0.97	0.87	1.09	0.97	0.87	1.09	0.97	0.87	1.09
Residential instability index	**0.84**	**0.74**	**0.96**				0.93	0.81	1.07	0.94	0.82	1.07	0.94	0.82	1.08
Racial/language homogeneity index	**0.77**	**0.71**	**0.84**				0.93	0.86	1.02	0.93	0.86	1.01	0.93	0.85	1.01
Homicide index	1.00	1.00	1.00				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Interactions for subgroups															
<u>Access to Transport (Yes)</u>															
(NHB vs. NHW)										0.70	0.50	1.00			
(Hispanics vs. NHW)										1.00	0.71	1.42			
(Haitian vs. NHW)										**0.53**	**0.35**	**0.79**			
<u>Access to Transport (No)</u>															
(NHB vs. NHW)										**0.28**	**0.10**	**0.77**			
(Hispanics vs. NHW)										**0.36**	**0.13**	**0.95**			
(Haitian vs. NHW)										**0.17**	**0.05**	**0.54**			
<u>Distance to ADAP (median distance >8.0 Miles)</u>															
(NHB vs. NHW)													**0.48**	**0.29**	**0.79**
(Hispanics vs. NHW)													0.73	0.45	1.20

(Haitian vs. NHW)	0.56	0.29	1.07
Distance to ADAP (median distance ≤ 8.0 Miles)			
(NHB vs. NHW)	0.79	0.50	1.26
(Hispanics vs. NHW)	1.04	0.66	1.64
(Haitian vs. NHW)	**0.50**	**0.31**	**0.80**

NHB: Non-Hispanic Black; NHW: Non-Hispanic White; MSM: Men who have sex with men; FPL: Federal Poverty Level; IDU: Injection drug use; ACA: Affordable Care Act; SES: socioeconomic; MCM: Medical case management; ADAP: AIDS Drug Assistance Program

[a] = A higher index score for each index indicates increased social disadvantage/worse conditions

CONCLUSIONS

The objective of this dissertation was to assess the contribution of neighborhood, geographic, and distance factors on racial/ethnic disparities in achieving sustained viral suppression (all viral load results <200 copies/ml in a year) among Ryan White Program clients in Miami-Dade County. To address this objective, we used multi-level mixed effects models to estimate the association between individual and neighborhood level factors and sustained viral suppression. We also used geographic information system (GIS) tools to identify geographic disparities of sustained viral suppression, as well as to determine transportation and travel distance to HIV care facilities. This study had aimed to (1) identify the moderating effect of neighborhood disadvantage on the association between race/ethnicity and sustained viral suppression, (2) identify individual and neighborhood-level factors associated with residing in geographic hotspots of low sustained viral suppression, and (3) examine the moderating effect of race/ethnicity on the association between travel distance and access to transportation to HIV case management sites and AIDS Drug Assistance Program (ADAP) pharmacies and sustained viral suppression. We hypothesized that neighborhood disadvantage, residing in geographic hotspots of poor HIV care outcomes, and longer distance to care facilities will contribute to racial/ethnic disparities in achieving sustained viral suppression.

The first aim of this dissertation examined the moderating role of neighborhood disadvantage on the association between race/ethnicity and sustained viral suppression. We first identified three distinct neighborhood attributes using principal component analysis and categorized these attributes into tertiles: “low”, “moderate”, and “high”. High tertiles indicated higher levels of adverse negative social conditions. These attributes were composed of socioeconomic (SES) disadvantage index (comprised of twelve variables regarding poverty, income disparity, education, employment and occupation,

public assistance, vehicle ownership, and crowding), residential instability index (comprised of rented housing and mobility), and racial/language homogeneity index (comprised of English language proficiency and percentage of population that are non-Hispanic black). Overall, we found that neighborhood-level factors were not associated with sustained viral suppression. However, we were able to find racial/ethnic disparities in sustained viral suppression within different levels of neighborhood characteristics in Miami-Dade County. These findings disprove our hypothesis of racial/ethnic disparities being larger in areas of higher neighborhood disadvantage. For example, we observed that racial/ethnic minorities, particularly non-Hispanic Blacks (NHB) and Haitians, were less likely to achieve sustained viral suppression in low or moderate SES disadvantaged neighborhoods, moderate residential instability neighborhoods, as well as in low or high racial/language homogeneity neighborhoods when compared to non-Hispanic Whites (NHW) in similar neighborhoods.

Our finding that racial/ethnic minorities have poor sustained viral suppression in neighborhoods that are characterized by less disadvantaged neighbohoods is not consistent with prior studies, which have stated that poor HIV care outcomes were observed in more disadavntaged neighborhoods (Eberhart et al. 2015a; Wiewel et al. 2017a). This indicates that disparities in sustained viral suppression might be largely driven by other factors. These may include individual level factors such as poor medication adherence, due to medication fatigue or side effects or drug resistance, psychosocial factors as well health care environment/clinic factors which may pose a unique challenge for people with HIV (PWH). Additonally racial/ethnic disparities in wealthier neighborhoods might also be attributed to discrimination towards minorities as well as policies and practices that we were not able to assess in our study.

While our study did not find a notable association in disadvantaged neighborhoods, it is important to address the role and influence of community-level disadvantage on health outcomes for marginalized populations. Racial/ethnic minorities, particularly Blacks, usually reside in economically and socially deprived neighborhoods, which are often characterized by limited social, economic, and medical resources (Kerr et al. 2015b), such as by poverty, unemployment, housing instability, crime, mass incarceration, and lack health care access. It is important to address these social inequities to address the disparities observed in HIV care outcomes among minorities in Miami-Dade County. One of the key drivers of a disadvantaged neighborhood is poverty. Poverty decreases access to care, increases risk of unstable housing and food insecurity, and often exacerbates management of HIV care and treatment (Phillips et al. 2021). Hence, it's important to take measures to improve poverty levels. Expansion of government funded program such as the Earned Income Tax Credit and other social safety net programs in the US might alleviate poverty and have a long-term impact on health outcomes. Policies targeted at improving education and employment contribute to economic growth within resource-deprived neighborhoods, which further alleviates disparities caused due to poverty. Examining the feasibility and acceptability of evidence-based programs such as the Health Resource and Service Administration's "Homeless Initiative" and the Enhanced Housing Placement Assistance Program in New York, which target housing insecurity, might be important to implement in Miami Dade County (Centers for Disease Control and Prevention 2021b). Additionally improving economic conditions through investments, increased wages, expanded health care, and reforming criminal justice systems, in these neighborhoods might alleviate poverty related disparities among racial/ethnic minorities in order to achieve and maintain a consistently suppressed viral load.

We also found that racial/ethnic minorities in high racial/language homogeneity neighborhoods (high concentration of NHB and those that speak English well) were less likely to achieve sustained viral suppression when compared to NHW in similar neighborhoods. An important root-cause of racial/ethnic disparities is racial residential segregation. Segregation has systematically disadvantaged minorities and resulted in increased concentrated poverty, lack of generational wealth, and systemic housing discrimination. Moreover, segregation also leads to prejudice, discrimination, and stigma for minorities, particularly Blacks. Discriminatory policies, particularly those in housing and zoning/land use should be eliminated to dismantle segregation. In more better-off neighborhoods, discrimination and stigma can also lead to racial/ethnic disparities leading to poor HIV care outcomes. Historic medical research alongside with discrimination and unfair treatments for Blacks has led to distrust in the medical system including providers, HIV treatments, and health care received (Earnshaw et al. 2015). Discrimination affects the human stress response, which is determinantal to achieving optimal health outcomes (Pellowski et al. 2013). Enacted stigma experienced by minorities as well as HIV-related stigma and structural stigma contribute to the inequities observed in care outcomes. Policies, practices, and norms at the societal level that contribute to structural stigma need to be identified and addressed (Hatzenbuehler 2016). Interventions that are targeted towards stigma and discrimination reduction in specific priority areas and population are needed. Some strategies include programs that assist institutions to recognize stigma within their services, addressing social stigma in the community through creating an inclusive environment, respond to the specific needs of stigmatized populations, increasing education and awareness using various platforms including the media, and using peer support services (Pulerwitz et al. 2010).

The second aim of this dissertation identified geographic areas that were hotspots (i.e., had clusters) of poor sustained viral suppression using geographic information system tools and determined which individual and neighborhood level characteristics were associated with residing in these areas in Miami-Dade County. The results support our hypothesis that residing in geographic hotspots of poor sustained viral suppression would be associated with higher neighborhood-level disadvantage and higher concentration. Our findings identified specific areas mostly in the northern part of the county, in which one-third of the RWP clients in Miami-Dade County live. The overall characteristics of the population in the northern part of the county is primarily comprised of Blacks, US born, and those who speak another language besides English. Furthermore, these areas have higher rates of poverty. Hence it is important to implement programs that are targeted towards alleviating poverty in these areas. Further studies, including qualitative studies are vital to understand the unique socio-economic and health needs of people in these areas.

When only examining individual-level characteristics, people who were NHB and Haitian vs. NHW, who were US born vs. foreign born, who had a heterosexual mode of HIV exposure vs. men who have sex with men (MSM), and who had mental health symptoms were more likely to reside in geographic hotspots of poor sustained viral suppression. Our findings reveal that minority groups are more likely to reside in areas that have a lot of need for support programs to improve sustained viral suppression. Resource allocation and tailored interventions may be necessary to address the needs of these priority target populations through involvement of community partnerships and multi-sector collaborations. Some examples of scalable interventions for NHB include designing programs that work towards eliminating stigma and discrimination, building trust in the medical care system, and minimizing poverty and neighborhood segregation

may be beneficial towards achieving optimal health outcomes. For Haitians, designing interventions that are culturally appropriate, with regards to language, literacy, and health-beliefs are essential to eliminating barriers to care seeking behaviors and improving health outcomes. A study have shown that foreign born have better health outcomes when compared to US born (Demeke et al. 2019). This could be attributed to delayed diagnosis and needed immediate medical attention improving their linkage to care, retention in care and medication adherence (Demeke et al. 2019). However, prevention programs that target US born populations need to be investigated. Moreover, programs that aim to decrease barriers associated with immigration and documentation status are needed due to high percentage of immigrants in Miami-Dade County. Interventions specific to those that acquired HIV through heterosexual mode of transmission, particularly among racial/ethnic minorities, are crucial to understand factors that are influencing poor health outcomes within these specified geographic areas. Mental health, in particular depression, is a barrier to medication adherence and retention in care, which ultimately affects sustained viral suppression. Routine mental health screenings and mental health service programs should be strengthened in these geographic locations. Culturally responsive mental health treatment programs that incorporate non-traditional partners such as faith-based organizations, are key to addressing mental health within the Black community. Overall, evidence-based interventions that address particular groups of populations should be scaled-up county-wide.

When we included neighborhood characteristics in our analysis, we found that Haitians were more likely to reside in geographic hotspots of poor sustained viral suppression compared to NHW. Neighborhood level factors were also associated with residing in geographic hotspots of poor sustained viral suppression. High neighborhood

disadvantage, residential instability, and racial/language homogeneity (used as a proxy for segregation) were all associated with residing in geographic hotspots of poor sustained viral suppression. Interventions and program that work towards alleviating poverty, decreased policing and incarceration rates, minimizing housing instability and poor housing, dismantling structural segregation and racism, improving social cohesion/networks to minimize mobility, eliminating discriminatory policies and practices, as well as addressing structural stigma are needed to improve the health outcomes of populations residing in these neighborhoods.

In our third aim, we examined the moderating role of travel distance to HIV care facilities (Medical Case Management [MCM] site, and AIDS Drug Assistance Program [ADAP] pharmacies) as well as transportation needs on the association between race/ethnicity and achieving sustained viral suppression. We observed that most of our clients did not attend the nearest MCM site to seek care. We also found that racial/ethnic minorities without access to transportation had poor sustained viral suppression when compared to NHW without access to transportation. Poor sustained viral suppression was also observed for NHB and Haitians that travelled father away from their nearest MCM as well as for those that traveled more than the median distance of 7.2 miles to MCM sites when compared to NHW in the same travel predicament. These findings align with our original hypothesis that longer travel distance and lack of access to transportation to care facilities would be associated with poor sustained viral suppression. Even though location of facilities can be a barrier to accessing care, prior studies have documented that PWH traveled farther to seek care due to provider preference, fear of HIV-status disclosure, as well as needing additional ancillary services (Eberhart et al. 2014). Adequate geographical distribution of HIV health care service organization is critical. Expansion of mobile clinics or RWP subcontracted facilities that

provide a variety of ancillary services, as well as utilizing Federally Qualified Health Centers-look alike organizations to provide care for RWP clients might serve as a facilitator to ameliorate longer travel distance. Moreover, qualitative studies should be conducted to understand why clients do not attend the closest facility and if there are potential health care system structural changes to address these behaviors.

Our findings regarding lack of access to transportation contributing to poor health outcomes is consistent with prior studies (Syed, Gerber, and Sharp 2013). Having a reliable, adequate, and convenient mode of transportation, whether through personal vehicle or a family/friend's vehicle or public transportation, is an important social determinant of health. Lack of access to transportation is a barrier to engaging in continuous medical care, including keeping and attending medical appointments, accessing medication at pharmacies, and receiving timely care, which is needed for PWH. It is important to eliminate this modifiable barrier by providing clients with affordable transportation options. Distance to care facilities might be a barrier, particularly to low-income populations that do not have access to personal vehicles for transportation or cannot afford public transportation (Syed, Gerber, and Sharp 2013). Improving the public transportation infrastructure in Miami-Dade County would greatly benefit RWP clients who do not have access to a personal vehicle. Policy makers should work closely with urban planners and the public transportation system to design and implement additional transportation routes via buses, trains, light-rails, and ride-shares at affordable prices for low-income populations. Services such as public transit discounts, medical transportation services vouchers and reimbursement for travel should be expanded, particularly to RWP clients. Furthermore, expansion of telehealth services at an affordable rate or inclusion as part of RWP services might help alleviate transportation and distance related barrier.

The RWP provides clients with medication through their ADAP pharmacies. We examined travel distance to ADAP pharmacies by assessing the distance to the nearest ADAP pharmacy from a client's residential ZIP code centroid, even though we did not know which pharmacy the RWP clients utilized. In Miami-Dade County only two pharmacies were operating in 2017. Hours of operations, convenience, and safety of pharmacy location, coupled with the fear of HIV-status disclosure at ADAP pharmacy locations, might serve as barriers to achieving optimal care. Clients need to have options whether to assess their medication at a store or through the home-based delivery service. Hence, expansion of this program including utilizing commercial pharmacies is essential. Additionally, the administrative part of ADAP, which requires recertification to the program every 6 months may lead to discontinuation of medication access for RWP clients. Therefore, evaluation of these aspects of ADAP might minimize barriers to accessing medication and medication refills in Miami-Dade County.

This dissertation research is not without limitations. First, we defined neighborhoods using ZIP codes, which are used for postal service delivery rather than assessing population characteristics and may include multiple heterogeneous neighborhoods. Using administrative boundaries such as ZIP codes could lead to spatial misclassification, as clients are exposed to various neighborhoods/environments outside of their ZIP code of residency (Duncan et al. 2014). Second, this study is comprised of clients that are enrolled in the RWP, and the findings might not be generalizable to PWH who are not in the program or those that are not engaged in care through other government or private programs/insurance. Third, Miami-Dade County has a majority Hispanic and immigrant population. Hence, caution needs to be taken when generalizing the results to other urban counties in the US. Fourth, when analyzing travel distance, we only factored in distance from the centroid of clients residential ZIP code using a vehicle

as a mode of transportation and did not factor in clients travelling to care facilities from other locations, such as workplaces, as well as using public transportation. We did not have access to the client's actual address to measure distance. Moreover, we did not know which ADAP pharmacies clients used in 2017. As a result, distance traveled might not be accurate.

In summary, we observed significant differences in sustained viral suppression by race/ethnicity and geographic locations within Miami-Dade County among RWP clients. In order to end the HIV epidemic, it is important to address these disparities, not only at the individual level, but also at the structural level. Structural factors hinder care, decrease health opportunities, and increase disease exposure, especially for underserved and high-risk populations living with HIV. It is imperative to implement and support programs that address systemic and structural barriers to care through cross-sector collaborations, such as transportation barriers. Miami-Dade County's "Getting to Zero Initiative" has provided a set of recommendation to work towards ending the HIV epidemic in the county (Escudero et al. 2019). To address critical gaps in health care outcomes for PWH, efforts that address structural barriers should be incorporated and prioritized in this initiative.

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