ABSTRACT

Title of Dissertation: EXPLORING PSYCHOSOCIAL AND STRUCTURAL SYNDEMIC EFFECTS AS PREDICTORS FOR HIV-RELATED OUTCOMES AMONG BLACK WOMEN

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Black women continue to be disproportionately affected by HIV with marked disparities in HIV incidence, prevalence, and care outcomes. There is a critical need to explore the role of psychosocial and structural factors and the negative impact of these factors on HIV-related outcomes, including HIV risk behaviors, HIV medication adherence, and healthcare utilization. This research uses the syndemic theory to measure the effects of both psychosocial and structural syndemics on HIV-related outcomes among Black women. Syndemic theory is a theoretical framework, which posits there are multiple, overlapping factors that form a cumulative and synergistic effect on HIV disease burden. The substance abuse, violence and AIDS (SAVA) syndemic, clustering effects of substance use, intimate partner abuse, and HIV/AIDS, have been applied in studies exploring HIV outcomes among women; however, the SAVA syndemic framework does not include additional psychosocial and structural factors such as food

insecurity, housing instability, incarceration, post -traumatic stress disorder, and depression to better understand the syndemic profiles of Black women. Using study data from the HIV Prevention Trials Network 061 Women's Seroincidence study and the Women's Interagency HIV Study, we tested whether a cumulative syndemic of psychosocial and structural factors contributed to sexual risk behaviors and HIV care outcomes. The studies will assess three parameterizations of syndemic factors: cumulative syndemic index, syndemic group indices reflecting the level of influence (psychosocial, participant-level, and neighborhood), and number of syndemic groups (0, 1, 2, or 3). We also tested whether HIV status modified the relationships between a cumulative syndemic of psychosocial and structural factors and sexual risk behaviors.

In study 1, a higher syndemic score was significantly associated with increased prevalence of unknown HIV status of last male sex partner (aPR = 1.07, 95% CI: 1.04-1.10), engaging in exchange sex (aPR = 1.17, 95% CI: 1.14-1.20), and having multiple sex partners (aPR = 1.07, 95% CI: 1.06-1.09) among a sample of 1,347 Black women. In study 2, generalized linear mixed models found that being in two syndemic groups was associated with increased odds of reporting unknown HIV status of last male sex partners (aOR=3.04, 95% CI: 1.24-7.44) and having multiple sex partners (aOR=4.29, 95% CI: 1.81-10.18) among 1,364 Black women living with and without HIV across twelve follow-up visits. We also found that being in all three syndemic groups was associated with increased odds of reporting inconsistent condom use (aOR= 2.15, 95% CI: 1.28-3.61), unknown HIV status of last male sex partners (aOR=5.26, 95% CI: 1.94-14.25), and having multiple sex partners (aOR=7.47, 95% CI: 2.85-19.58). Among a total of 969 Black women living with HIV in study 3, a higher cumulative syndemic score and a higher neighborhood-level structural syndemic group score was associated with increased odds of reporting sub-optimal HIV medication adherence (aOR=1.04, 95% CI: 1.01-1.06 and 1.08,

respectively). Black women in all three syndemic groups had increased odds of reporting sub-optimal HIV medication adherence (OR=2.88, 95% CI: 1.32-6.29) and missed HIV appointments (OR=3.39, 95% CI: 1.06-10.92). Results from these studies highlight the evidence of psychosocial and structural syndemic effects on multiple HIV risk and care outcomes among Black women.

EXPLORING PSYCHOSOCIAL AND STRUCTURAL SYNDEMIC EFFECTS AS PREDICTORS OF HIV-RELATED OUTCOMES AMONG BLACK WOMEN

by

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Chapter 1: Introduction

Background and Rationale

Human immunodeficiency virus (HIV) continues to be a health issue that disproportionately affects people of color generally, and black people, specifically. In 2019, black people comprised 13% of the United States (US) population yet accounted for 55% of all HIV diagnoses.[1] Disparities among black people persist, not only in terms of incidence, but also prevalence, care outcomes, and mortality. Although black people experienced the largest decline in HIV death rates from 2010 to 2018, stark disparities between black people and their Hispanic/Latino and White counterparts persists. In 2018, the death rate among black people living with diagnosed HIV infection (16.3 per 100,000) was almost seven times that seen in White people (2.5 per 100,000) and almost 4 times that seen in Hispanic/Latino people (4.5 per 100,000).[1] Additionally, deaths among black people living with HIV contributed to 44.1% of all deaths among people living with HIV (PLWH).[1] Furthermore, compared to national estimates, black people living with diagnosed HIV are less likely to report receipt of HIV medical care (73.7% vs 75.7%), retention in care (55.8% vs 57.9%), and viral suppression (59.9% vs 64.7%).[2] The most recent data show that by the end of year 2018, the rate of living with diagnosed HIV among black people was 1,034.2 per 100,000 persons; almost seven times greater than the rate for Whites (154.0 per 100,000) and almost three times greater than the rate for Hispanics/Latinos (386.4 per 100,000).[1] Similar to disparities observed within the black population across HIV morbidity, mortality, and care outcomes, these

disparities are more pronounced when exploring HIV disparities among women, with disparities in HIV diagnoses, care, and treatment among Black women continuing, to persist, despite increased HIV prevention and intervention efforts.

For Black women , HIV morbidity and mortality rates mirror that of the black community, with Black women comprising 13% of the female population in the United States (US) yet accounting for approximately 58% of HIV diagnoses among all women.[1] Between 2012-2017, the largest decline in new HIV diagnoses in the US occurred among Black women ; however, Black women still had the highest number of diagnoses each year, conveying persistent disparities despite decreased HIV diagnoses.[1] In 2017, the HIV diagnosis rate for Black women was 24.9 per 100,000, a rate more than fourteen times that of the rate for White women (1.7 per 100,000) and almost five times that of the rate for Hispanic/Latino women (5.0 per 100,000).[3] Furthermore, a previous study exploring lifetime risk of HIV diagnosis found that Black women had a lifetime risk of being diagnosed with HIV of 1 in 54, whereas the lifetime risk among White women and Hispanic/Latina women was 1 in 941 and 1 in 256, respectively.[4] In addition to HIV diagnoses, Black women experience disparities in HIV prevalence and deaths. In 2017, there were 235,004 women living with diagnosed HIV, with Black women accounting for approximately 60% of these women.[1] Additionally, the death rate of Black women living with diagnosed HIV was 12.7 per 100,000, while the death rate of Hispanic/Latino women and White women were 1,7 per 100,000 and 0.9 per 100,000, respectively.[1]

Despite these marked disparities, there is evidence that there are no differences in individual risk behaviors among Black women compared to other

racial/ethnic groups that can explain higher rates of HIV.[5,6] Previous studies have shown that Black women were more likely to report condom use during heterosexual intercourse compared to women of other racial/ethnic groups.[7-9] This suggests that individual risk behaviors may not fully explain disparate rates of HIV among Black women , meaning that other factors must be taken into consideration to help develop a better understanding of contributing factors that may explain these disparities. The evaluation of psychosocial and social/structural vulnerabilities and their relationship to HIV-related outcomes may provide an additional insight for comprehensively examining the manifestations that are driving HIV disparities among Black women.

Social/structural vulnerabilities such as incarceration,[10] poverty,[11,12] food insecurity,[13-17] housing instability,[18-20] neighborhood disorder,[21,22] lack of health insurance,[11,12] and low access to health services[23] and psychosocial vulnerabilities occurring at intrapersonal (psychological and behavioral processes occurring within the individual such as depression[24-26]) and interpersonal (i.e., processes occurring as a result to relationships or interactions with other people such as violence victimization[27-33]) levels have been found to be related to poor HIV-related outcomes among Black women . Findings from previous studies indicate that PTSD and depressive symptoms are associated with presence of detectable viral load[34], low CD4 count,[34] medication non-adherence[34], and HIV risk behaviors,[35,36] and HIV acquisition.[37] Additionally, alcohol and drug use have been found to be associated with medication non-adherence,[38,39] viral suppression,[38-40] and increased HIV risk behaviors.[35,41]

When these psychosocial and social/structural factors intersect, they form a syndemic. A syndemic refers to the co-occurrence and synergistic effect with multiple factors that imposes an excess burden of disease vulnerability and has been put forth in the extant literature as a framework that can be applied to better understand HIV-related outcomes.[40,42,43-47]

Evaluating the factors that affect HIV risk not only contributes to the gap in epidemiological literature that focuses primarily on HIV among Black women , but also results in evidence-based perspectives when developing targeted prevention and intervention initiatives. Furthermore, it is imperative that HIV prevention and intervention programs extend beyond addressing behavioral factors (i.e., condomless sexual intercourse, multiple sex partners) and comprehensively address the social/structural determinants driving HIV disparities. It is unclear how social determinants of health influence HIV risk among Black women . Important questions to examine among Black women is the extent to which differences exist within the societies in which they live and the extent to which social determinants of health contribute to the continued high rates of HIV acquisition among Black women .

Objective of the Research

The objective of this research is to examine how psychosocial and structural factors create a syndemic that influences HIV-related outcomes among Black women . Structural factors will be explored in two levels: participant-level and census tract-level, hereinafter referred to as neighborhood structural factors.

In **study 1**, the psychosocial factors of interest include ongoing violence, history of childhood abuse, depressive symptoms, post-traumatic stress disorder

(PTSD) symptoms, illicit drug use, and heavy alcohol use; the participant-level structural factors of interest include lack of health insurance, incarceration, unstable housing, and food insecurity; and the neighborhood structural factors of interest include concentrated rental-burdened households, neighborhood low educational attainment, neighborhood unemployment, concentrated housing vacancy, neighborhood black racial concentration, and concentrated income inequality.

In **study 2,** the psychosocial factors of interest include history of intimate partner abuse, history of childhood sexual abuse, depressive symptoms, high severity of post-traumatic stress disorder (PTSD) symptoms, illicit drug use, and heavy alcohol use; the participant-level structural factors of interest include incarceration, annual household income less than $24,000, lack of health insurance, unstable housing, and food insecurity; and the neighborhood-level structural factors of interest include concentrated rental-burdened households, neighborhood low educational attainment, neighborhood unemployment, concentrated housing vacancy, neighborhood black racial concentration, concentrated poverty, and concentrated income inequality.

In **study 3,** the psychosocial factors of interest include history of intimate partner abuse, history of childhood sexual abuse, depressive symptoms, perceived HIV-related discrimination in health care settings, high internalized HIV-related stigma, illicit drug use, and heavy alcohol use; the participant-level structural factors of interest include incarceration, annual household income less than $24,000, lack of health insurance, unstable housing, and food insecurity; and the neighborhood-level structural factors of interest include concentrated rental-burdened households,

neighborhood low educational attainment, neighborhood unemployment, concentrated housing vacancy, neighborhood black racial concentration, concentrated poverty, concentrated income inequality, and concentrated uninsurance.

While previous research has examined the clustering effects of substance abuse, violence, and HIV/AIDS, known as the SAVA syndemic, among women,[45] few studies have explored factors beyond SAVA-related factors to better understand HIV-related outcomes among women of color. Poverty, victimization, depression, substance use, incarceration, and homelessness/housing instability have independently been found to be associated with HIV outcomes among Black women ,[11-13,18,20,24-31,33] therefore, providing evidence that the SAVA syndemic may not fully represent the complete syndemic profile of HIV risk among Black women .

Study 1 employs a cross-sectional analysis to assess the relationship between the syndemic of psychosocial, participant-level structural, and neighborhood-level structural factors on HIV risk behaviors (i.e., condomless vaginal sex at last intercourse, condomless anal sex at last intercourse, unknown HIV status of last male sex partner, exchange sex for money or commodities, and multiple sex partners) reported at baseline.

Study 2 longitudinally explores the syndemic of psychosocial, participant-level structural, and neighborhood-level structural factors and how these factors are associated with HIV risk behaviors including inconsistent condom use, unknown HIV status of last male sex partners and multiple sex partners over time among HIV-negative and HIV-positive Black women .

Study 3 longitudinally explores the relationship between a syndemic of psychosocial, participant-level structural, and neighborhood-level structural factors on HIV care outcomes (i.e., sub-optimal HIV medication adherence, missed HIV care appointments, and sub-optimal healthcare utilization).

Theoretical Frameworks and Hypotheses

This research builds on the frameworks of both intersectionality and syndemic theory. Intersectionality is a theoretical framework for understanding how multiple social identities such as race, class, and gender intersect and how this intersection influences the individual experiences in the macro social-structural world, in terms of oppression and privilege.[48] Intersectionality is unique in understanding the experiences of Black women and health because it does not treat the social identities of Black women as unidimensional and independent of each other, but instead as identities (i.e., race and gender) that are continuously intersecting with each other and influencing a black woman's experiences taking into account the oppressive structures of privilege, microaggressions, racism, and discrimination. However, the intersectionality framework was never intended to predict health outcomes;[48] thereby limiting the application of the framework in epidemiological modeling.

Syndemic theory is a theoretical framework that has been applied to HIV risk by exploring multiple, co-occurring factors that synergistically reinforce each other and increase disease vulnerability.[42,43,49] The clustering effects of substance use, intimate partner abuse, and HIV/AIDS has been referred to as the SAVA syndemic.[44-47,50] The SAVA syndemic framework has been applied to a plethora of studies when exploring HIV outcomes among women; however, the SAVA syndemic framework

does not include pertinent psychosocial and structural factors such as food insecurity, housing instability, incarceration, post -traumatic stress disorder, and depression that have been found to be associated with HIV acquisition. Based on this syndemic framework, it is hypothesized in all studies that psychosocial, participant-level structural, and neighborhood-level structural factors will be correlated with each other, thereby providing evidence of a syndemic.

In study 1, it is hypothesized that that higher cumulative syndemic effect of psychosocial, participant-level structural, and neighborhood-level structural factors is associated with higher prevalence of condomless vaginal sex at last intercourse, condomless anal sex at last intercourse, unknown HIV status of last male sex partner, exchange sex for money or commodities, and multiple sex partners

In study 2, it is hypothesized that a higher cumulative syndemic effect of psychosocial, participant-level structural, and neighborhood-level structural factors associated with increased odds of reporting inconsistent condom use, unknown HIV status of last male sex partners, and multiple sex partners among HIV positive and HIV negative Black women in the WIHS data. Additionally, an interaction effect with HIV status will be assessed to determine whether the syndemic effect of psychosocial, participant-level structural, and neighborhood-level structural factors on sexual risk behaviors is modified by HIV status.

Lastly in study 3, it is hypothesized that among Black women living with diagnosed HIV, a higher cumulative syndemic of psychosocial, participant-level structural, and neighborhood-level structural factors is positively associated with sub-

optimal medication adherence, missed HIV appointments, and sub-optimal healthcare utilization.

Additionally, all studies will categorize each psychosocial and structural syndemic factor into one of three syndemic groups reflecting the level of influence: psychosocial group (i.e., abuse, depressive symptoms, PTSD symptoms, drug and alcohol use), participant-level structural group (i.e., lack of health insurance, incarceration, unstable housing, food insecurity), and neighborhood-level structural group (i.e., concentrated cost burden households, neighborhood unemployment, concentrated poverty). Examination of whether exposure to none, one, two, or three syndemic groups is associated with the study outcomes will also be assessed in each study. Therefore, as a secondary hypothesis, it is hypothesized that Black women exposed to multiple syndemic groups will have increased associations with study outcomes.

Innovation and Significance

The innovation and significance of this research lies in the exploration of psychosocial and structural factors that extend beyond the SAVA syndemic. The SAVA syndemic has been widely applied to previous research exploring HIV among women of color--providing evidence that substance use and intimate partner abuse greatly influences HIV outcomes among women of color.[40,44] However, poverty, depression, incarceration, and homelessness/housing instability have not only been found to be independently associated with HIV risk behaviors and care outcomes among women, but also can be mutually reinforcing; thereby, providing evidence for

further exploration of these factors as syndemics. This research comprehensively aims to use the syndemic theory to better define HIV risk for Black women by assessing factors that extend beyond SAVA-related factors. Assessment of psychosocial and structural factors and how they work in tandem to influence HIV outcomes among Black women will advance the current understanding of syndemic effects, as well as the development of comprehensive and combined HIV prevention strategies that address the multitude of levels that are driving the HIV disparity among Black women.

Chapter 2: Methods

Study Design

Data Source

Study 1 utilizes a cross-sectional study design, sampling from the HPTN 064 Women's HIV Seroincidence study (HPTN 064). The HPTN 064 study was a large multi-site, longitudinal study conducted to estimate the overall HIV-1 incidence rate among US women living in areas characterized by high HIV prevalence rates and poverty.[51] The study was conducted in Atlanta, Georgia; Baltimore, Maryland; New York, New York; Newark, New Jersey; Raleigh/Durham, North Carolina; and Washington, DC between May 2009 and July 2010 and consisted of an enrollment visit (baseline), as well as a 6-month and 12-month follow-up visit. During the enrollment, 6-month, and 12-month follow-up visits, study participants received HIV rapid testing and completed assessments using audio computer-assisted self-interview (ACASI) technology. Additionally, study participant's residential addresses were obtained at baseline and were linked to a census tract using the US Census Bureau geocoder.

Studies 2 and 3 utilizes the Women's Interagency HIV study (WIHS), a multisite, prospective cohort study of HIV-seropositive and HIV-seronegative cisgender women designed to explore HIV progression in women.[52] WIHS participants were enrolled during 4 waves: 1994–95, 2001–02, 2011–12, and 2013–15, and from 10 study sites (San Francisco/Bay Area, CA; Bronx/ Manhattan, NY; Brooklyn, NY; Washington, DC; Chicago, IL; Chapel Hill, NC; Atlanta, GA; Miami,

FL; Birmingham, AL; Jackson, MS).[53] Study participants were administered a scripted interview, clinical examinations, and laboratory testing at every 6-month follow-up visit. Study questionnaires are available at https://statepi.jhsph.edu/wihs/wordpress/?page_id=455. Residential addresses at baseline were geocoded to census tracts for WIHS study participants who provided written informed consent.

To create the neighborhood structural variables for all of the studies, data from the U.S. Census Bureau's American Community Survey (ACS) will be merged with geocoded HPTN 064 participant data (Study 1) and geocoded WIHS participant data (Studies 2 and 3) at the census tract level. ACS is an ongoing nationwide survey that aims to provide a more statistically accurate picture of the demographic, social, economic, and housing characteristics of the communities we live in.[54] In study 1, the neighborhood structural variables were created using the ACS 5-year estimates from 2007-2011. In studies 2 and 3, the neighborhood structural variables were created using the ACS 5-year estimates from 2010-2014, 2011-2015, 2012-2016, 2013-2017, 2014-2018, and 2015-2019. Each WIHS visit where participant address information was collected was linked to the 5-year ACS corresponding to the current year of the study visit (i.e., study visits between April 2014-September 2014 was linked to the 2014 ACS 5-year estimates; study visits between April 2015-September 2015 was linked to the 2015 ACS 5-year estimates)

Participants and Criteria for Selection

Study 1 is limited to non-Hispanic cisgendered Black women , aged 18 years and older, who met the HPTN 064 eligibility criteria and whose residential addresses were able to be geocoded. The total analytic sample size was 1,347 Black women in HPTN 064 at baseline.

Study 2 is limited to HIV-seropositive and HIV-seronegative non-Hispanic cisgendered Black women , aged 30 years and older, who met the WIHS eligibility criteria and whose residential addresses were able to be geocoded. The total analytic sample size was 1,364 Black women including 960 HIV-seropositive and 404 HIV-seronegative women. Lastly, study 3 is limited to HIV-seropositive non-Hispanic cisgendered Black women , aged 30 years and older, who met the WIHS eligibility criteria and whose residential addresses were able to be geocoded. The analytic sample was restricted to a total of 969 black HIV-seropositive WIHS participants.

Outcome Variables

In study 1, the outcome variables are the following HIV risk behaviors reported at baseline and assessed as occurring in the past six months including condomless vaginal sex at last intercourse, condomless anal sex at last intercourse, unknown HIV status of last male sex partner, exchange sex, and multiple sex partners.

In study 2, the outcome variables are the sexual risk behaviors reported at biannual follow-up visits including inconsistent condom use, unknown HIV status of last male sex partners, and multiple sex partners.

In study 3, the outcome variables are the HIV care outcomes reported at biannual follow-up assessments including sub-optimal HIV medication adherence, missed HIV appointments, and sub-optimal healthcare utilization.

Outcome variables in all the studies were coded with a binary coding structure of 1=Yes and 0=No. Additionally, all outcome variables were self-reported; therefore, a potential measurement issue is response bias. Response bias may have occurred due to study participants not truthfully answering questions about the outcome variables, as many are sensitive in nature. Furthermore, social desirability bias could be present because participants may have reported socially acceptable behaviors rather than their true HIV risk behaviors.

Exposure Variables

In study 1, the psychosocial and structural factors hypothesized to form a syndemic included ongoing violence, history of childhood abuse, depressive symptoms, PTSD symptoms, illicit drug use, and heavy alcohol use; the participant-level structural factors of interest include lack of health insurance, incarceration, unstable housing, and food insecurity; and the neighborhood structural factors of interest include concentrated rental-burdened households, neighborhood low educational attainment, neighborhood unemployment, concentrated housing vacancy, neighborhood black racial concentration (as a proxy for residential segregation), and concentrated income inequality.

In study 2, the psychosocial and structural factors hypothesized to form a syndemic included history of intimate partner abuse, history of childhood sexual

abuse, depressive symptoms, high severity of PTSD symptoms, high perceived stress, illicit drug use, and heavy alcohol use; the participant-level structural factors of interest include incarceration, annual household income less than $24,000, lack of health insurance, unstable housing, and food insecurity; and the neighborhood-level structural factors of interest include concentrated rental-burdened households, neighborhood low educational attainment, neighborhood unemployment, concentrated housing vacancy, neighborhood black racial concentration, concentrated poverty, and concentrated income inequality.

In study 3, the psychosocial and structural factors hypothesized to form a syndemic included history of intimate partner abuse, history of childhood sexual abuse, depressive symptoms, perceived HIV-related discrimination in health care settings, high internalized HIV-related stigma, illicit drug use, and heavy alcohol use; the participant-level structural factors of interest include incarceration, annual household income less than $24,000, lack of health insurance, unstable housing, and food insecurity; and the neighborhood-level structural factors of interest include concentrated rental-burdened households, neighborhood low educational attainment, neighborhood unemployment, concentrated housing vacancy, neighborhood black racial concentration, concentrated poverty, concentrated income inequality, and concentrated uninsurance.

Exposure variables in all the studies were coded with a binary coding structure of 1=Yes and 0=No, thereby standardizing the coding structure of each psychosocial and structural variable.

Potential Confounders and Effect Modifiers

In study 2, the effect modifier of interest is HIV status which is coded as 1=HIV-positive and 0=HIV-negative. HIV status was assessed as an effect modifier to test whether the longitudinal relationships between a cumulative psychosocial and structural syndemic and sexual risk behaviors differ by HIV status. The HIV status interaction terms were not statistically significant in any of the study models; therefore, HIV status was included in adjusted models as a potential confounder.

In study 1, adjusted models included study site, participant's age, education level, and household income as covariates. In study 2, covariates included participant's age, education level, employment status, and HIV status and were controlled for in adjusted models. In study 3, covariates included participant's age, education level, and employment status. Study covariates were chosen *a priori* based on previous literature that included these potential confounders in models evaluating HIV-related outcomes.

Statistical Approaches

Power Analysis: Study 1

In Study 1, a total of 2,099 participants were enrolled in HPTN 064 Women's HIV Seroincidence study. Of those, 1,347 non-Hispanic, cis-gender Black women were included in this study. Based on preliminary analysis using HPTN 064 data, outlined in Table 1, the prevalence of HIV risk behaviors (i.e., condomless vaginal intercourse, condomless anal intercourse, concurrent sexual partnerships, sexual partner with unknown HIV status, exchange sex, and multiple sex partners) among

Black women ranged from 39.3%-81.6%. Table 1 lists the prevalence of these HIV risk behaviors reported at baseline among Black women enrolled in the HPTN 064 study and included in this study. A power analysis was used to determine the sample size needed to achieve reasonable power (0.80) and a prevalence ratio of at least 1.5. For an HIV risk behavior prevalence of 39.3%, a total sample size of 264 is needed to have 90% power to detect prevalence ratios of 1.5. For an HIV risk behavior prevalence of 81.4%, a total sample size of 501 is needed to have 90% power to detect prevalence ratios of 1.5. We will achieve an appropriate sample size as the total sample size of Black women in this study is 1,347.

Table 1: Baseline Prevalence of HIV Risk Behaviors among Eligible Black women in the HIV Prevention Trials Network 064 Women's HIV Seroincidence Study (N=1,347)

Variables	Prevalence
Condomless Vaginal Intercourse	81.6%
Condomless Anal Intercourse	81.3%
Sexual Partner with Unknown HIV Status	46.1%
Exchange Sex	39.3%
Multiple Sex Partners	61.0%

Power Analysis: Study 2

In Study 2, there were 1,425 Black women included in the study analyses. When stratified by HIV status, there were 432 HIV-positive Black women and 982 HIV-negative Black women . Table 2 lists the prevalence of HIV risk behaviors for

eligible Black women in WIHS at baseline stratified by HIV status. Among the full sample HIV risk behavior prevalence ranged from 12.2%-17.8%. For an HIV risk behavior prevalence of 12.2%, a total sample size of 513 is needed to have 90% power to detect odds ratios of 1.5. For an HIV risk behavior prevalence of 17.8%, a total sample size of 389 is needed to have 90% power to detect odds ratios of 1.5. We will achieve an appropriate sample size for Study 2 as the total of Black women to be included in this analysis is 1,425.

Among HIV-positive Black women in the study, prevalence of HIV risk behavior ranged from 14.6%-20.6%. For an HIV risk behavior prevalence of 14.6%, a total sample size of 381 is needed to have 85% power to detect odds ratios of 1.5. For an HIV risk behavior prevalence of 20.6%, a total sample size of 302 is needed to have 85% power to detect odds ratios of 1.5. An appropriate sample size for Study 2 is likely to be achieved as the total of HIV-positive Black women to be included in this analysis is 432.

Among HIV-negative Black women in the study, prevalence of HIV risk behaviors ranged from 11.3%-17.6%. For an HIV risk behavior prevalence of 11.3%, a total sample size of 466 is needed to have 85% power to detect odds ratios of 1.5. For an HIV risk behavior prevalence of 17.6%, a total sample size of 337 is needed to have 85% power to detect odds ratios of 1.5. An appropriate sample size for Study 2 is likely to be achieved as the total of HIV-positive Black women to be included in this analysis is 982.

Table 2: Baseline Prevalence of Sexual Risk Behaviors among HIV-Positive and HIV-Negative Black women in the Women's Interagency HIV Study			
	Total Sample (N=1,425)	**HIV-Positive Black women (N=432)**	**HIV-Negative Black women (N=982)**
Variables	**Prevalence**	**Prevalence**	**Prevalence**
Inconsistent condom use	17.8%	18.5%	17.6%
Unknown or positive HIV status of partner	12.2%	14.6%	11.3%
Multiple sex partners	16.9%	20.6%	15.5%

In study 3, a total of 969 Black women were included in the analyses. Table 3 lists the prevalence of the study outcomes reported at baseline among eligible Black women in WIHS and included in this analysis with the prevalence of HIV care outcomes ranging from 9.8%-16.8%. A power analysis was used to determine the sample size needed to achieve reasonable power (0.80) and an odds ratio of at least 1.5. For an HIV care outcome prevalence of 9.8%, a total sample size of 765 is needed to have 95% power to detect odds ratios of 1.5. For an HIV care outcome prevalence of 16.8%, a total sample size of 499 is needed to have 95% power to detect odds ratios of 1.5. We will achieve an appropriate sample size as the total sample size of Black women in this study is 969.

Table 3: Baseline Prevalence of HIV Care Outcomes among HIV-Positive Black women in the Women's Interagency HIV Study	
Variables	**Prevalence**
Sub-optimal HIV Medication Adherence	16.8%
Missed HIV appointments	12.1%
Sub-optimal Healthcare Utilization	9.8%

Statistical Analysis

In all studies, the frequencies and percentages of each psychosocial and structural variable and outcome variable reported at baseline were summarized. Additionally, the mean and standard deviation was calculated for the cumulative syndemic score and each individual syndemic group score. The correlations between each psychosocial and structural variable reported at baseline will be assessed by generating unadjusted models. The studies will assess three parameterizations of syndemic factors: cumulative syndemic index, syndemic group indices reflecting the level of influence (psychosocial, participant-level, and neighborhood), and number of syndemic groups (0, 1, 2, or 3). The unadjusted and adjusted relationships between each syndemic parameterization and HIV risk behaviors (Study 1 and 2) and HIV care outcomes (Study 3) were generated.

Model Specifications

In study 1, log binomial regression models were conducted to estimate prevalence ratios comparing each HIV risk behavior outcome for each syndemic parameterization. Unadjusted and adjusted models were generated for all models with

the adjusted model accounting for study site, participant's age, education level, and household income.

In study 2, a series of generalized linear mixed models with the logit link function and random effect for slope and intercept were conducted to test for longitudinal effects of syndemic parameterizations on sexual risk behaviors. Trajectory effects of syndemic parameterizations on sexual risk behaviors were included in the models by including an interaction term (e.g., cumulative syndemic count*time). Adjusted models controlled for participant's age, education level, employment status, and HIV status.

In study 3, a series of generalized linear mixed models were conducted to measure trajectory effects of the three syndemic parameterizations on sub-optimal HIV medication adherence, missed HIV appointments, and sub-optimal healthcare utilization. Study covariates included participant's age, education level, and employment status.

Assessment of Model Assumptions

In all studies, outliers were assessed by using three methods: Cook's distance, leverages, and studentized residuals. If any given observation was identified as an outlier by any method, the observation would have been removed from the data to acquire a more accurate model; however, there was no evidence of overly influential observations. Variance inflation and multicollinearity of each psychosocial and structural exposure variable was assessed by measuring the variance inflation factor (VIF) values. Variables with a VIF greater than 5 would have been removed from the

model to reduce jeopardizing the stability and robustness of the models; however, there was no evidence of variance inflation. In study 1, missing data was addressed with multiple imputation using the Markov Chain Monte Carlo method assuming an arbitrary missing pattern. Values that were imputed were truncated to fit within the range of possible values and were rounded to the nearest whole number. The use of multiple imputation has been used in several studies to produce robust and unbiased parameter estimates.[123-124] Studies 2 and 3 utilized a complete case analysis because missingness across psychosocial and structural was low, less than 8%.

Overall Study Strengths and Limitations

These studies allow for the exploration of psychosocial and multilevel structural factors, the formulation of a syndemic, and how these cumulative syndemic effects influence HIV risk behaviors (Study 1 and 2) and HIV care outcomes (Study 3). There have been few studies investigating the relative impact of such syndemic effects; therefore, the expected findings will fill important gaps in the literature and better inform HIV prevention and intervention programs that directly address the lived experiences of Black women . Additionally, a strength of these studies is the sample size. The large sample sizes in each study ensures adequate power, thereby producing more reliable and precise effect estimates.

These studies are not without limitation, The neighborhood structural factors obtained from the ACS included in these studies may not fully represent the extent of neighborhood structural characteristics that impose on Black women 's engagement in sexual risk behaviors. Additionally, study variables were self-reported by the study participant introducing the possibility of bias and misclassification. Recall bias, a type

of exposure identification bias, may have occurred due to study participants not being able to recall accurate information. Furthermore, social desirability bias could also be present because participants may have reported socially acceptable behaviors.

Chapter 3: Going Beyond SAVA: Exploring Psychosocial and Structural Syndemic Effects as Predictors of HIV Risk Behaviors among Black women (Manuscript 1)

Abstract

HIV continues to disproportionately affect Black women in the United States. These disparities may be influenced by psychosocial and structural factors that shape HIV risk behaviors. Using data from the HIV Prevention Trials Network 064 Women's Seroincidence study (HPTN 064) and the American Community Survey 5-year estimates from 2007-2011, clustered log-binomial analyses were conducted to measure the relationship between a cumulative syndemic of psychosocial and structural factors and HIV risk behaviors including condomless anal sex at last intercourse, condomless vaginal sex at last intercourse, unknown HIV status of last male sex partner, exchange sex, and multiple partners among 1,347 non-Hispanic Black women enrolled in HPTN 064. A higher syndemic score was significantly associated with increased prevalence of unknown HIV status of last male sex partner (aPR = 1.07, 95% CI: 1.04-1.10), exchange sex (aPR = 1.17, 95% CI: 1.14-1.20), and multiple sex partners (aPR = 1.07, 95% CI: 1.06-1.09). Findings from this study highlight the role psychosocial and multilevel structural (i.e., participant and neighborhood) syndemic characteristics that cumulatively influence the lived experiences of Black women and the complex and interrelated connections these factors contribute to shaping HIV risk.

INTRODUCTION

HIV continues to disproportionately affect Black women in the United States, who in 2017 had an estimated HIV incidence rate of 24.9 per 100,000 women. This rate was 14 times higher than the estimated HIV incidence rate for White women (1.7 per 100,000) and almost 5 times more than the estimated HIV incidence rate for Hispanic/Latino women (5.0 per 100,000).[3]

Despite these disparate rates, evidence has shown there are no differences in Black women 's individual risk behaviors compared to women of other racial groups that can explain the disproportionately higher HIV rates.[5,6] This evidence conveys how critical it is to identify additional factors outside of behavior such as psychosocial and structural factors that may influence HIV risk among Black women and serve as targets for future interventions. Existing evidence supports that psychosocial and structural factors including intimate partner abuse, unstable housing, and higher neighborhood levels of unemployment contribute to increased risk of HIV.[7]

Psychosocial factors have been found to be significantly associated with sexual risk behaviors For example, the presence of depressive symptoms is associated with less condom use, as well as having multiple sex partners.[24,25] Previous studies have shown that women who reported violent victimization experiences such as childhood sexual abuse and intimate partner violence were more likely to report early sexual debut,[27,28] multiple sex partners,[27-29] substance use,[27,28,30] involvement in exchange sex,[28] history of sexually transmitted infections,[29,31] and condomless

sex.[29,32] Additionally, socioeconomic factors have been associated with HIV risk. HIV surveillance data examining HIV diagnoses and social determinants of health convey that HIV diagnosis rates among women were highest in census tracts with the highest levels of poverty and highest percentage of those without health insurance; and lowest levels of education attainment and median household income.[12] In a study exploring HIV prevention among women with a history of incarceration, history of incarceration was found to be significantly associated with less condom use, involvement in exchange sex, and increased risk of HIV acquistion.[10] In the HPTN 064 Women's HIV Seroincidence study where one of the eligibility criteria included living in a census tract or zip code with high HIV prevalence and poverty, HIV incidence was estimated to be 0.24%, an estimate that was five times greater than the national estimate of HIV incidence among Black women .[55] Despite the extensive evidence that shows psychosocial and structural factors are independently associated with HIV risk behaviors; little is known about how these factors converge and create a syndemic that may increase HIV risk behaviors among Black women .

Syndemic theory is a theoretical framework that has been the foundation of studies exploring multiple co-occurring factors that are hypothesized to increase disease vulnerability.[42,43,49] A syndemic has been defined as "two or more epidemics, interacting synergistically and contributing, as a result of their interaction, to excess burden of disease in a population." [42,43,49] Studies that have used the syndemic framework to evaluate HIV-related outcomes among black populations have provided valuable insights on the importance of exploring the synergistic effects of individual-level factors on HIV-related outcomes.[56] However, there continues to be a need to

explore the synergistic role of place-based factors (i.e., neighborhood poverty, neighborhood housing instability) on HIV risk behaviors to better explain the multi-level factors shaping HIV disparities among Black women . Previous studies that have examined syndemics among women have applied the SAVA syndemic, which refers to the clustering effect of substance abuse, violence, and, HIV/AIDS;[40,44-46,50] however, psychosocial (e.g., post-traumatic stress disorder) and structural factors at the individual and neighborhood levels (e.g., unstable housing, food insecurity, neighborhood poverty, neighborhood unemployment) are not included as factors to be considered within the SAVA syndemic framework. Analytical approaches to modeling syndemics have included the sum score approach to estimate the additive effects of variables, factor analyses to investigate the correlations between syndemic variables, and latent class analyses to identify distinct syndemic risk classes or clusters. Although there are multiple ways to measure syndemics, the sum score approach remains the dominant methodology used in research and continues to show that the number of adverse events have a dose response relationship with health outcomes.[40,57-60]

In this study, we aim to measure the additive effects of multiple psychosocial and structural factors on HIV risk behaviors; therefore, we extend the SAVA framework to include structural and psychosocial factors to create a cumulative syndemic index. The development of a novel syndemic profile, which includes psychosocial and structural factors, can serve as a useful construct for understanding HIV risk in Black women . Using data from the HIV Prevention Trials Network 064 Women's Seroincidence Study (HPTN 064), we will measure the cross-sectional

relationship between a cumulative syndemic of psychosocial and structural factors and HIV risk behaviors among Black women . Similar to a previous study investigating syndemic factors among women at risk for HIV,[57] the present study will also categorize each psychosocial and structural syndemic factor into one of three syndemic groups reflecting the level of influence: psychosocial, participant-level structural, and neighborhood structural; therefore, the study will test the relationship between each syndemic group and HIV risk behaviors. Lastly, the study will measure the magnitude of the relationship between experiencing none, one, two, or three syndemic groups and HIV risk behaviors to assess whether experiencing multiple syndemic groups is associated with higher prevalence of reporting HIV risk behaviors.

METHODS

Participants

This study utilizes a cross-sectional study design, sampling from the HIV Prevention Trials Network 064 Women's HIV Seroincidence study (HPTN 064). HPTN 064 was a large multi-site, longitudinal study conducted to estimate the overall HIV-1 incidence rate among US women living in areas characterized by high HIV prevalence rates and poverty.[55] The study was conducted in Atlanta, Georgia; Baltimore, Maryland; New York, New York; Newark, New Jersey; Raleigh/Durham, North Carolina; and Washington, DC. Using venue-based, time-space sampling methods, women living in census tracts or zip codes that ranked in the top 30th percentile of HIV prevalence and with more than 25% of residents living below the

U.S. federal poverty threshold, as defined by the 2008 U.S. Census Bureau were recruited to participate in the study.[51,55]

Eligible participants were self-identified as women; aged between 18 and 44 years at study enrollment; willing to take an HIV test and receive results; resided in a study location; reported at least one instance of unprotected vaginal or anal sex with a man in the prior six months; reported at least one additional high risk characteristic (e.g., illicit drug use, history of sexually transmitted infections) that she or a partner engaged in in the prior six months; and provided informed consent.[62]

HPTN 064 study participants were enrolled between May 2009 and July 2010, completing an enrollment visit (baseline), as well as a 6-month and 12-month follow-up visits. During the enrollment, 6-month, and 12-month follow-up visits, study participants received HIV rapid testing and completed assessments using audio computer-assisted self-interview (ACASI) technology. Additionally, study participant's residential addresses were obtained at baseline and were linked to a census tract using the US Census Bureau online geocoder.

A total of 2,099 women were enrolled in HPTN 064; however, this analysis is limited to non-Hispanic cisgendered Black women who met the HPTN 064 eligibility criteria and whose residential addresses were able to be geocoded. The final analytic sample size was 1,347 Black women .

To create the neighborhood structural variables, study participant data was merged at the census tract level with data from the U.S. Census Bureau's American Community Survey (ACS). The ACS is an ongoing nationwide survey that aims to

provide a more statistically accurate picture of the demographic, social, economic, and housing characteristics of the communities we live in.[54] The census tract level variables used in this study were obtained from the ACS using 5-year estimates from 2007-2011.

Measures

Outcome Variables

The outcome variables were the HIV risk behaviors reported at baseline and assessed as occurring in the past six months including condomless vaginal sex at last intercourse, condomless anal sex at last intercourse, unknown HIV status of last male sex partner, exchange sex for commodities such as money, drugs, and goods, and multiple sex partners. Each variable was treated as a separate outcome variable and was coded with the binary coding structure of 1=Yes and 0=No.

Condomless vaginal sex at last intercourse was derived from a measure asking participants if they used a condom during vaginal sex with a man in the past 6 months. Responses were reverse coded such that "No" responses were recoded as 1=Yes for condomless vaginal sex at last intercourse and "Yes" responses were recoded as 0=No for condomless vaginal sex at last intercourse.

Condomless anal sex at last intercourse was participants if they used a condom during anal sex with a man in the past 6 months. Similar to condomless vaginal sex at last intercourse, responses were reverse coded such that "No" responses were recoded as 1=Yes for condomless vaginal sex at last intercourse and

“Yes” responses were recoded as 0=No for condomless vaginal sex at last intercourse.

Unknown HIV status of last male sex partner was derived from two measures asking participants “The last time you had vaginal sex with a man in the last 6 months, did you know his HIV status?” and “The last time you had anal sex with a man in the last 6 months, did you know his HIV status?” Responses included “HIV-negative,” “HIV-positive,” “I didn’t know,” and “I asked, but he didn't know/didn't tell me.” Participants who responded with “I didn’t know” or “I asked, but he didn't know/didn't tell me” for either question was recoded as 1=Yes for unknown HIV status of last male sex partner; all other responses were coded as 0=No.

Exchange sex for commodities such as money, drugs, and goods was derived from four measures asking participants “Of the men you have had sex with in the last 6 months, how many did you have sex with because you: needed a place to stay; needed food or other things for yourself and/or your family (like groceries, clothing, things for your kids); needed money; and needed drugs?” Responses indicating at least 1 partner for either question was reported as 1=Yes for exchange sex; responses indicating zero partners for all 4 measures were coded as 0=No.

Multiple sex partners was defined as the study participant indicating more than one male sex partner for the following question, “In the last 6 months how many different men have you had sex with?” Responses indicating at least two male sex partners were coded as 1=Yes. Responses indicating zero or one male sex partner was coded as 0=No.

Exposure Variables

Psychosocial Variables

Ongoing abuse was measured by self-reporting at least one experience of emotional abuse, physical violence, or forced sex in the prior six months using the following 3 questions for which responses were coded Yes or No: (1) “in the last six months, have you been emotionally abused by your partner or someone important to you? Examples of emotional abuse include: when someone makes you feel bad about yourself by calling you names, making you think you are crazy, humiliating you, making you feel guilty;” (2) “in the last six months, have you been hit, slapped, kicked, or physically hurt by someone important to you,” and (3) “in the last six months, have you been forced to have any type of sex?” These three measures demonstrated moderate internal consistency reliability (Cronbach’s alpha = 0.62). The variable was coded 1 = Yes for participants that responded Yes to at least one of the current partner abuse questions and coded 0=No for participants who responded No to all current partner abuse questions.

History of childhood abuse was measured using one dichotomous question that asked the participant “As a child, (less than 18) were you abused physically, emotionally, or sexually?” The variable was coded 1=Yes and 0=No.

Depressive symptoms were measured using a shortened eight-item version of the Center for Epidemiologic Studies Depression scale (CES-D).[63] The eight-item CES-D scale demonstrated high internal consistency (Cronbach’s alpha = 0.91) in this sample. The shortened version of the CES-D scale has been used in previous

studies that assess depressive symptoms among young Black women .[64] A score of 7 or greater was indicative of depressive symptoms, and thus was coded 1=Yes. A CES-D score less than 7 was coded as 0=No.

Post-traumatic stress disorder (PTSD) symptoms were assessed using the four-item Primary Care PTSD Screening tool.[65] The four-item measure demonstrated high internal consistency (Cronbach's alpha=0.79). The presence of PTSD symptoms was indicative of a score of 3 or greater.[18,66,67] A score of 3 or greater was coded as 1=Yes and a score of less than 3 was coded as 0=No.

Heavy alcohol use and illicit drug use was assessed using a modified version of the World Health Organization Alcohol, Smoking and Substance Involvement Screening Test scale.[68] Heavy alcohol use was measured by asking participants, "How often do you have four or more drinks on one occasion?" with responses ranging from never to four or more times a week. In the current study, heavy alcohol use was transformed into a binary variable where participant responses indicating consuming four or more drinks on one occasion at least two times per week were coded as 1=Yes and responses indicating consuming less than 4 drinks were coded as 0=No.

Illicit drug use was measured by asking "in the past six months, how often have you used [illicit drugs]?" with responses ranging from never to daily or almost daily. Similar to heavy alcohol use, illicit drug use was transformed into a binary variable where participant responses ranging from weekly to daily or almost daily

were coded as 1=Yes and responses indicating never, once or twice, and monthly were coded as 0=No.

Participant-level Structural Variables

Incarceration was measured by self-reporting incarceration in jail or prison at least once in the prior five years for which responses were coded 1=Yes and 0=No.

Food insecurity was measured by asking study participants, “In the past 6 months, have you been concerned about having enough food for you and/or your family?” for which responses were coded as 1=Yes and 0=No.

Lack of health insurance was measured by asking study participants, “Have you had any type of health insurance in the last 6 months? (When we say health insurance this includes Medicaid, Medicare, HMOs, private or commercial health insurance).” Responses were reverse coded such that a “No” response for health insurance was recoded as 1=Yes for lack of health insurance.

Unstable housing was coded as 1=Yes if study participants reported they were living at a friend's house or apartment, a halfway house or treatment center, a homeless shelter, a motel/hotel, or on the street in the last 6 months. Likewise, unstable housing was coded as 0=No if the study participant reported living in a home or apartment that they or a parent, partner, or spouse rented or owned.

Neighborhood Structural Variables

Neighborhood structural variables were constructed by linking participant’s geocoded addresses to census tracts using the American Community Survey (ACS) 5-

year estimates from 2007-2011. Each variable was dichotomized to 1=Yes and 0=No.

Concentrated rental burdened households were operationalized as living in a census tract where 50% or more of residents are paying 30% or more of income on rent.

Neighborhood unemployment was operationalized as living in a census tract where 15% or more of residents, 16 years and older, were unemployed.

Neighborhood low educational attainment was operationalized as living in a census tract where 25% or more of residents had less than a high school diploma.

Concentrated housing vacancy was defined as living in a census tract where 15% or more of vacant residential housing units are present.

Neighborhood black racial concentration was defined as living in a census tract where 50% or more of residents were black/African American. Neighborhood black racial concentration was used a proxy for black racial segregation.[69]

Concentrated income inequality was defined as living in a census tract with a Gini coefficient of 0.44. Gini coefficients range from 0 to 1, with 0 indicating complete equality and 1 indicating complete inequality. High income inequality has been identified as 0.44.[69]

Statistical Analysis

The prevalence of psychosocial and structural syndemic variables, and outcome variables reported at baseline were summarized by calculating frequencies

and percentages. The mean and standard deviation were calculated for the cumulative syndemic index. Relationships between each psychosocial and structural factor were assessed by generating a relationship matrix using unadjusted log-binomial regression models. There will be three syndemic parameterizations applied in this analysis. First, a cumulative syndemic index was created by summing the psychosocial and structural variables, with a range of 0-16. The binary coding structure of these variables (e.g., responses are within a range of 0 to 1) allow for standardization, making it so that no one factor is worth more than the others. Second, the psychosocial and structural syndemic factors will be categorized into three syndemic groups reflecting the level of influence: a psychosocial syndemic group which includes ongoing abuse, history of childhood abuse, depressive symptoms, PTSD symptoms, illicit drug use, and heavy alcohol use; a participant-level structural syndemic group which includes lack of health insurance, incarceration, unstable housing, and food insecurity; and a neighborhood structural syndemic group which includes concentrated rental-burdened households, neighborhood unemployment, neighborhood low educational attainment, concentrated housing vacancy, neighborhood black racial concentration, and concentrated income inequality. Lastly, we examined the exposure to none, one, two, or three syndemic groups.

Unadjusted and adjusted log-binomial regression models were run to estimate prevalence ratios measuring the associations between each HIV risk behavior outcome and syndemic parameterization. Covariates including study site, age, education, and household income will be controlled for in adjusted models. Outliers were assessed by measuring Cook's distance, leverages, and studentized residuals;

there was no evidence of overly influential observations. Variance inflation and multicollinearity were assessed by measuring the variance inflation factor (VIF) values; results indicated that there was no evidence of variance inflation (VIF > 5). Missing data was addressed with multiple imputation using the Markov Chain Monte Carlo method assuming an arbitrary missing pattern. Values that were imputed were truncated to fit within the range of possible values and were rounded to the nearest whole number to have the binary coding structure.

All analyses were conducted using log-binomial regression models with generalized estimating equations and an independent correlation structure to account for clustering by census tract. Models generated prevalence ratios (PR) with 95% confidence intervals (CIs). SAS Studio (SAS Institute, Inc., Cary, NC) was used to conduct all analyses.

RESULTS

A total of 2,099 participants were enrolled in the HPTN 064 study. Of those, 1,747 were identified as non-Hispanic, cis-gender Black women . Our study includes data from 1,347 Black women . Data from 400 Black women were excluded in this analysis due to the inability to match participant's geocoded address with ACS census-tract data (N=170) and participant's geocoded addresses recorded at the zip code level rather than the census-tract level (N= 230).

Of the 1,347 Black women included in this analysis, 36% of women were aged between 35 and 44 years. Most Black women in this analysis were high school graduates (40.2%) and had an annual household income of less than $10,000 (72.0%).

At baseline, a large proportion of Black women were living in census tracts characterized by concentrated rental burdened households (67.7%), neighborhood unemployment (76.5%), concentrated housing vacancy (76.3%), neighborhood black racial concentration (90.8%), and concentrated income inequality (62.0%). On average, Black women in this analysis experienced 7 syndemic factors. Additionally, 63.4% of women experienced syndemics in at least 2 syndemic groups (Table 1).

A large proportion of Black women in the sample reported condomless vaginal intercourse (81.6%), condomless anal intercourse (81.3%), and having multiple male sex partners (61.0%) in the last six months. Almost half of the sample reported unknown HIV status of last male sexual partner (46.1%), while 39.3% of Black women reported engaging in exchange sex in the last six months (Table 1).

Table 2 shows the matrix of bivariate associations between each psychosocial and structural syndemic variable reported at baseline. Most psychosocial and structural variables were significantly associated with each other. Strong associations were observed between depressive symptoms and ongoing abuse (PR = 2.02, 95% CI: 1.75-2.34), PTSD and ongoing abuse (PR = 2.09, 95% CI: 1.83-2.38), PTSD and depressive symptoms (PR = 3.22, 95% CI: 2.79-3.73), incarceration and illicit drug use (PR = 2.68, 95% CI: 2.17-3.31), food insecurity and PTSD (PR = 2.04, 95% CI: 1.72-2.44), concentrated housing vacancy and neighborhood low educational attainment (PR = 2.30, 95% CI: 1.88-2.83), and neighborhood black racial concentration and neighborhood unemployment (PR = 3.77, 95% CI: 2.70-5.27).

Table 3 shows the prevalence ratios between each syndemic parameterization and HIV risk behavior. When adjusted for study site, age, income, and education, a higher syndemic score was significantly associated with increased prevalence of unknown HIV status of last male sex partner (aPR = 1.07, 95% CI: 1.04-1.10), exchange sex (aPR = 1.17, 95% CI: 1.14-1.20), and having multiple sex partners (aPR = 1.07, 95% CI: 1.06-1.09). This observation persisted for the psychosocial and participant-level structural syndemic groups. A higher syndemic score in the psychosocial syndemic group was associated with increased prevalence of unknown HIV status of last male sex partner (aPR = 1.12, 95% CI: 1.09-1.16), exchange sex (aPR = 1.27, 95% CI: 1.23-1.32), and multiple sex partners (aPR = 1.11, 95% CI: 1.09-1.14). Similarly, a higher syndemic score in participant-level structural syndemic group was associated with increased prevalence of unknown HIV status of last male sex partner (aPR = 1.15, 95% CI: 1.09-1.22), exchange sex (aPR = 1.36, 95% CI: 1.29-1.44), and multiple sex partners (aPR = 1.17, 95% CI: 1.13-1.22). A dose-response relationship was observed between the number of syndemic groups and HIV risk behaviors. Being in all three syndemic groups was associated with increased prevalence of unknown HIV status of last male sex partner (aPR = 1.67, 95% CI: 1.43-1.95), exchange sex (aPR = 3.07, 95% CI: 2.51-3.77), and multiple sex partners (aPR = 1.53, 95% CI: 1.36-1.72). There were no statistically significant associations observed between syndemic parameterizations and condomless anal and vaginal sex.

DISCUSSION

This analysis provides evidence that a syndemic of psychosocial and structural factors exist among a cohort of non-Hispanic Black women in the HPTN064 study.

Furthermore, the cumulative effect of these syndemic factors were associated with multiple HIV risk behavior outcomes. Findings from this analysis provides preliminary evidence that Black women experience multiple manifestations at the individual and neighborhood levels that influence health outcomes.

Black women in this study experienced a range of psychosocial and structural factors including depression,[24-26] incarceration,[10] history of childhood sexual abuse,[28,30,31] and neighborhood disorder[21] that have been found to be independently associated with HIV risk behaviors. Many of the psychosocial and structural variables were correlated with each other, providing evidence that the study variables are mutually enhancing; thereby forming a syndemic. On average, women in the analysis reported experiencing seven syndemic variables.

In the analysis, there was a positive relationship between the cumulative syndemic index score and HIV risk behavior outcomes. The prevalence of reporting unknown HIV status of last male sex partner, exchange sex, and multiple sex partners increased as the number of syndemic factors increased. This finding is consistent with previous studies among urban women[57], Latino MSM[70], transgender women.[71] There was no statistically significant relationship observed between the cumulative syndemic index score and condomless sex. This finding was not consistent with previous studies, however, 82% of Black women in the study reported condomless vaginal sex at last intercourse and 81% of Black women in the study reported condomless anal sex at last intercourse; therefore, this unexpected finding may be the result of a homogenous sample.

In addition, the findings highlight the role neighborhood characteristics play in the lived experiences of Black women and the complex and interrelated connections these factors share with other syndemic factors that have been found to shape HIV risk. In this analysis, structural factors were explored at the individual and neighborhood levels. Previous studies have found a relationship between psychosocial and individual structural syndemic effects and HIV risk behaviors;[57] however, there is limited evidence including neighborhood-level structural characteristics in a syndemic index. When categorized into syndemic groups, the neighborhood structural syndemic group was not statistically significant with any of the HIV risk behavior outcomes; however, a statistically significant dose-response relationship was observed between number of syndemic groups and HIV risk behaviors, except condomless anal and vaginal sex. These findings suggest that the cumulative effect of neighborhood level variables alone do not influence HIV risk but work in tandem with co-occurring psychosocial and individual-level variables to predict HIV risk behavior outcomes.

This study is not without limitations. First, the HPTN 064 Women's HIV Seroincidence study specifically recruited women from six urban and peri-urban cities who were behaviorally high-risk. This affects the external validity of the findings because study findings are unable to be generalized to all Black women in the United States. Secondly, because this analysis only included data collected at baseline, the analysis is cross-sectional in nature and therefore is unable to infer causality and temporality. This is important because without the ability to determine causality and temporality, it is impossible to determine the direction of observed

associations. Longitudinal analyses are ideal in further examining the relationship between syndemic effects and HIV risk behaviors over time. Finally, social desirability bias may have occurred when obtaining data on psychosocial and structural syndemic variables and HIV risk behavior outcomes, as participants may have provided socially acceptable responses to questions.

CONCLUSION

The present study provides evidence that psychosocial and structural factors work in tandem and form a syndemic and that the plurality of HIV disparities among Black women are disparities stemming from the convergence of psychosocial and structural factors such as abuse, depression, incarceration, food insecurity, and neighborhood unemployment. Findings from this study demonstrate the need for the application of a syndemic framework in further analyses to better define HIV risk profiles among Black women. Longitudinal studies are needed to better understand the longitudinal impact of a syndemic consisting of psychosocial and structural factors on risk behaviors facilitating HIV transmission. Study findings also highlight how critical it is in implementing not only comprehensive HIV prevention initiatives that should address social and structural manifestations, but also policy initiatives that place poor neighborhood conditions at the forefront.

Table 1: Syndemic and HIV risk behavior characteristics reported at baseline among non-Hispanic Black women in the HPTN 064 cohort study

Demographic Characteristics	**N (%)**
Age Group (N=1347)	
18-24 years	408 (30.3)
25-34 years	451 (33.5)
35-44 years	486 (36.1)
45+ years	2 (0.2)
Annual Household Income (N=877)	
< $10,000	631 (72.0)
$10,000-$20,000	131 (14.9)
$20,001-$40,000	84 (9.6)
$40,001-$60,000	21 (2.4)
$60,001-$80,00	8 (0.9)
>$80,000	2 (0.2)
Education Status (N=1347)	
Less than HS Diploma	484 (35.9)
HS graduate	542 (40.2)
Some College	237 (17.6)
Vocational School	64 (4.8)
College Graduate and Above	20 (1.5)

Variables Reported in last 6 months	
Psychosocial Characteristics	
Ongoing Abuse (N=1331)	
Yes	495 (37.2)
No	836 (62.8)
History of Childhood Abuse (N=1323)	
Yes	588 (44.4)
No	735 (55.6)
Depressive Symptoms (N=1316)	
Yes	440 (33.4)
No	876 (66.6)
Post-Traumatic Stress Disorder (PTSD) symptoms (N=1331)	
Yes	387 (29.1)
No	944 (70.9)
Illicit Drug Use (N=688)	
Yes	291 (42.3)
No	397 (57.7)
Heavy Alcohol Use (N=1122)	
Yes	317 (28.3)
No	805 (71.8)

Structural Factors	
Participant-level Characteristics	
Incarceration (in last 5 years) (N=1347)	
Yes	547 (40.6)
No	800 (59.4)
Food Insecurity (N=1327)	
Yes	607 (45.7)
No	720 (54.3)
Unstable Housing (N=1324)	
Yes	203 (15.3)
No	1121 (84.7)
Health Insurance Status (N=1292)	
Has Health Insurance	431 (33.4)
Does Not Have Health Insurance	861 (66.6)
Neighborhood-level Characteristics (N=1347)	
Concentrated rental burdened households *(living in a census tract where 50% or more of residents are paying 30% or more of income on rent)*	
Yes	912 (67.7)
No	435 (32.3)
Neighborhood low educational attainment *(living in a census tract where 25% or more of residents had less than a high school diploma)*	

Yes	632 (46.9)
No	715 (53.1)
Neighborhood unemployment *(living in a census tract where 15% or more of residents, 16 years and older, were unemployed)*	
Yes	1031 (76.5)
No	316 (23.5)
Concentrated housing vacancy *(living in a census tract where 15% or more of vacant residential housing units are present)*	
Yes	1028 (76.3)
No	319 (23.7)
Living in census tracts with neighborhood black racial concentration *(living in a census tract where 50% or more of residents were black/African American)*	
Yes	1223 (90.8)
No	124 (9.2)
Concentrated income inequality *(living in a census tract with a Gini coefficient of 0.44)*	
Yes	835 (62.0)
No	512 (38.0)
Syndemic Parameterizations	
Cumulative Syndemic Score, M (SD)	7.4 (2.5)
Psychosocial Syndemic Group Score, M (SD)	1.8 (1.6)
Participant level Syndemic Group Score, M (SD)	1.3 (1.0)

Neighborhood-level Syndemic Group Score, M (SD)	4.2 (1.2)
Number of Syndemic Groups (N=1347)	
0	8 (0.6)
1	485 (36.0)
2	506 (37.6)
3	348 (25.8)
Sexual Characteristics (reported in past 6 months)	
Condomless Vaginal Intercourse (N=1331)	
Yes	1086 (81.6)
No	245 (18.4)
Condomless Anal Intercourse (N=541)	
Yes	399 (81.3)
No	92 (18.7)
Unknown HIV Status of Last Sexual Partner (N=1327)	
Yes	620 (46.1)
No	724 (53.9)
Exchange Sex (N=1327)	
Yes	522 (39.3)
No	805 (60.7)
Multiple Sex Partners (2 or more partners) (N=1324)	

Yes	808 (61.0)
No	516 (39.0)

Table 2: Bivariate prevalence ratios between each psychosocial and structural syndemic factor at baseline

	Ongoing abuse	History of Childhood Abuse	Depressive Symptoms	PTSD	Illicit Drug Use	Heavy Alcohol Use	Incarceration	Food Insecurity	Unstable Housing	Lack of Health Insurance	Concentrated Rental Cost Burdened	Neighborhood low educational attainment	Neighborhood Unemployment	Concentrated Housing Vacancy	Neighborhood Black Racial Concentration
History of Childhood Abuse	2.02*** (1.75-2.34)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Depressive Symptoms	1.91*** (1.67-2.18)	1.65*** (1.47-1.85)	—	—	—	—	—	—	—	—	—	—	—	—	—
PTSD	2.09*** (1.83-2.38)	1.87*** (1.67-2.09)	3.22*** (2.79-3.73)	—	—	—	—	—	—	—	—	—	—	—	—
Illicit Drug Use	1.20* (1.03-1.40)	1.15* (1.00-1.31)	1.97*** (1.70-2.27)	1.76*** (1.49-2.08)	—	—	—	—	—	—	—	—	—	—	—
Heavy Alcohol Use	1.21* (1.04-1.40)	1.17* (1.03-1.34)	1.60*** (1.38-1.87)	1.69*** (1.43-1.99)	1.78*** (1.46-2.18)	—	—	—	—	—	—	—	—	—	—
Incarceration	1.14 (0.99-1.31)	1.08 (0.96-1.22)	1.45*** (1.24-1.68)	1.37** (1.16-1.61)	2.68*** (2.17-3.31)	1.25* (1.03-1.50)	—	—	—		—	—	—	—	—
Food Insecurity	1.86*** (1.61-2.14)	1.47*** (1.30-1.66)	1.97*** (1.68-2.31)	2.04*** (1.72-2.44)	1.64*** (1.34-2.01)	1.39** (1.15-1.68)	1.20** (1.05-1.36)	—	—	—	—	—	—	—	—
Unstable Housing	1.23* (1.04-1.46)	1.24** (1.07-1.44)	1.24* (1.03-1.50)	1.53*** (1.26-1.85)	1.92*** (1.55-2.37)	1.38** (1.09-1.73)	1.39*** (1.19-1.61)	1.25** (1.08-1.44)	—	—	—	—	—	—	—
Lack of Heath Insurance	1.12 (0.97-1.30)	1.03 (0.91-1.18)	1.22* (1.04-1.42)	1.05 (0.88-1.26)	1.69*** (1.39-2.06)	1.42** (1.18-1.72)	1.35*** (1.19-1.54)	1.04 (0.92-1.18)	1.39* (1.08-1.80)	—	—	—	—	—	—
Concentrated Rental cost burdened	1.22* (1.04-1.43)	1.12 (0.98-1.27)	1.08 (0.91-1.27)	0.95 (0.80-1.14)	0.90 (0.73-1.10)	0.95 (0.78-1.16)	1.01 (0.88-1.15)	0.92 (0.81-1.04)	0.81 (0.62-1.05)	1.34** (1.12-1.60)	—	—	—	—	—
Neighborhood low educational attainment	0.94 (0.82-1.09)	1.01 (0.90-1.14)	1.15 (0.99-1.34)	1.05 (0.89-1.24)	1.24* (1.02-1.51)	0.90 (0.75-1.09)	1.13 (0.99-1.28)	0.96 (0.85-1.08)	0.92 (0.71-1.19)	1.09 (0.93-1.27)	0.86*** (0.79-0.92)	—	—	—	—
Neighborhood Unemployment	1.06 (0.90-1.26)	0.87** (0.76-0.99)	0.94 (0.79-1.12)	0.84 (0.70-1.02)	1.01 (0.79-1.28)	0.90 (0.72-1.10)	0.87* (0.75-1.00)	0.96 (0.84-1.10)	0.49*** (0.38-0.63)	0.85 (0.72-1.01)	1.26*** (1.13-1.39)	1.35** (1.15-1.58)	—	—	—
Concentrated Housing Vacancy	1.02 (0.87-1.21)	1.03 (0.89-1.19)	1.10 (0.91-1.32)	0.98 (0.80-1.19)	1.20 (0.94-1.54)	1.08 (0.86-1.35)	1.12 (0.95-1.31)	0.88 (0.77-1.00)	1.16 (0.85-1.58)	1.22* (1.00-1.49)	1.38*** (1.24-1.55)	2.30*** (1.88-2.83)	0.97 (0.91-1.04)	—	—
Neighborhood Black Racial concentration	0.94 (0.75-1.19)	0.95 (0.78-1.16	1.01 (0.77-1.32)	0.93 (0.70-1.23)	1.30 (0.88-1.93)	1.17 (0.82-1.66)	0.97 (0.78-1.20)	1.08 (0.87-1.34)	0.79 (0.53-1.17)	0.71** (0.57-0.88)	1.41** (1.18-1.70)	0.79** (0.67-0.93)	3.77*** (2.70-5.27)	1.20** (1.05-1.37)	—
Concentrated Income Inequality	0.90 (0.78-1.03)	1.12 (0.99-1.27)	1.16 (0.99-1.37)	1.07 (0.90-1.28)	1.27* (1.02-1.57)	1.13 (0.93-1.38)	1.08 (0.94-1.24)	1.04 (0.92-1.18)	1.27 (0.97-1.67)	1.00 (0.85-1.17)	0.88** (0.82-0.94)	1.17* (1.04-1.33	1.04 (0.97-1.10)	0.94* (0.88-0.99)	1.11*** (1.06-1.15)

***p<.05, **p<.01, ***p<.001**

Table 3: Prevalence ratios and 95% confidence intervals for the associations between psychosocial and structural syndemic factors and HIV risk behaviors among Black women

	Condomless Anal Sex at last intercourse		**Condomless Vaginal Sex at last intercourse**		**Unknown HIV status of last male sex partner**		**Exchange sex**		**Multiple Sex Partners**	
Syndemic Variables	PR (95% CI)	aPR (95% CI)	PR (95% CI)	aPR (95% CI)	PR (95% CI)	aPR (95% CI)	PR (95% CI)	aPR (95% CI)	PR (95% CI)	aPR (95% CI)
Cumulative Syndemic Score	1.00 (0.98-1.01)	0.99 (0.98-1.01)	1.00 (1.00-1.02)	1.00 (0.99-1.01)	**1.08 (1.06-1.11)**	**1.07 (1.04-1.10)**	**1.20 (1.18-1.23)**	**1.17 (1.14-1.20)**	**1.07 (1.06-1.09)**	**1.07 (1.06-1.09)**
Psychosocial Syndemic Group Score	1.01 (0.98-1.03)	1.00 (0.98-1.03)	1.01 (1.00-1.03)	1.01 (0.99-1.02)	**1.14 (1.11-1.18)**	**1.12 (1.09-1.16)**	**1.32 (1.28-1.36)**	**1.27 (1.23-1.32)**	**1.11 (1.08-1.14)**	**1.11 (1.09-1.14)**
Participant-level Structural Syndemic Group Score	0.99 (0.95-1.03)	0.98 (0.94-1.03)	1.00 (0.97-1.02)	0.99 (0.97-1.02)	**1.18 (1.12-1.25)**	**1.15 (1.09-1.22)**	**1.44 (1.37-1.53)**	**1.36 (1.29-1.44)**	**1.17 (1.13-1.22)**	**1.17 (1.13-1.22)**
Neighborhood-level Structural Syndemic Group Score	0.98 (0.96-1.01)	0.98 (0.96-1.01)	1.01 (0.99-1.03)	1.00 (0.98-1.02)	1.02 (0.98-1.07)	1.01 (0.96-1.06)	1.01 (0.96-1.07)	1.01 (0.96-1.07)	1.00 (0.97-1.04)	0.99 (0.96-1.03)
Number of Syndemic Groups										
0-1	REF	REF	REF	REF	REF	REF	REF	REF	REF	REF
2	1.02 (0.92-1.13)	1.00 (0.90-1.11)	1.00 (0.94-1.06)	0.99 (0.93-1.05)	**1.47 (1.26-1.72)**	**1.41 (1.21-1.65)**	**2.28 (1.84-2.82)**	**2.10 (1.70-2.59)**	**1.36 (1.21-1.52)**	**1.37 (1.22-1.53)**
3	0.99 (0.89-1.10)	0.96 (0.86-1.08)	1.00 (0.93-1.06)	0.97 (0.91-1.04)	**1.77 (1.52-2.06)**	**1.67 (1.43-1.95)**	**3.56 (2.91-4.35)**	**3.07 (2.51-3.77)**	**1.55 (1.38-1.73)**	**1.53 (1.36-1.72)**

*Estimates where p<.05 are bolded to facilitate interpretation.
*Adjusted models are controlled for study site, age, education, and household income
*Five models were fit for each outcome: one with cumulative syndemic score, one with psychosocial syndemic group score, one with participant-level structural syndemic group score, one with neighborhood-level syndemic group score, and one with syndemic group number

Chapter 4: Exploring Longitudinal Psychosocial and Structural Syndemic Effects on Sexual Risk Behaviors among Black women Living With and Without HIV (Manuscript 2)

Abstract

Several factors operating on multiple levels shape Black women 's vulnerability to HIV risk and acquisition. There is limited evidence on the longitudinal associations of psychosocial and structural syndemics and sexual risk behaviors. Filling this gap in the literature, this longitudinal analysis included data from 960 HIV-positive and 404 HIV-negative Black women in the Women's Interagency HIV study. Study data was linked to six consecutive versions of the 5-year American Community Survey estimates for the development of neighborhood-level structural variables. Generalized linear mixed models were conducted to measure trajectory effects of psychosocial and structural syndemics on sexual risk behaviors, including inconsistent condom use, unknown HIV status of last male sex partner, and having multiple male sex partners. Being in two syndemic groups was associated with increased odds of reporting unknown HIV status of last male sex partners (aOR=3.04, 95% CI: 1.24-7.44) and multiple sex partners (aOR=4.29, 95% CI: 1.81-10.18) during follow-up visits. Being in all three syndemic groups was associated with increased odds of reporting inconsistent condom use (aOR= 2.15, 95% CI: 1.28-3.61), unknown HIV status of last male sex partners (aOR=5.26, 95% CI: 1.94-14.25), and multiple sex partners (aOR=7.47, 95% CI: 2.85-19.58). Study findings provide evidence of persistent effects of syndemic factors occurring on multiple levels, intersecting with each other, and influencing sexual risk behaviors.

INTRODUCTION

There is growing evidence that suggests multilevel manifestations shape women's HIV vulnerability. Geographic areas characterized by high levels of poverty, residential segregation, and incarceration rates have been found to be associated with sexual risk behaviors such as condomless sexual intercourse and multiple sex partners.[21,72,73] Social determinant of health factors such as poverty and lack of health insurance has been found to be associated with mortality among Black women living with HIV.[11]

Identifying and understanding how psychosocial and structural factors synergistically converge with one another and drive HIV disparities among Black women is critically important in developing comprehensive HIV prevention and intervention programs that addresses the proximate and distal forces negatively impacting Black women 's lived experiences. The synergistic relationship of substance abuse, violence, and AIDS, referred to as the SAVA syndemic, among women has been extensively explored to explain the relationship between syndemics and sexual risk behaviors.[40,44-47,50] A syndemic has been defined as "two or more epidemics, interacting synergistically and contributing, as a result of their interaction, to excess burden of disease in a population."[42,43] Previous studies have demonstrated robust associations between cumulative syndemic effects and sexual risk behaviors.[35,36,41,46,57]

Psychosocial and structural factors have also been found to be independently associated with HIV risk behaviors. For example, the presence of depressive

symptoms and post-traumatic stress disorder (PTSD) has shown to be associated with increased sexual risk behaviors, including inconsistent condom use, multiple sex partners, and unknown HIV-seropositivity status of sex partner.[24-26,74] History of incarceration has also been shown to be associated with less condom use, exchange sex, and increased risk of HIV acquistion.[10] In a longitudinal study examining the relationship between food insecurity and substance use in women at risk for HIV, women who reported low levels of food security had increased odds of illicit substance use.[13] Similarly, recent studies have provided evidence on the associations between psychosocial and structural factors and sexual risk behaviors among women living with and without HIV. Census-tract level analyses have found neighborhood social disorder to be associated with decreased condomless anal intercourse among women living with and without HIV.[21]

Previous studies that have examined syndemic effects among women have historically applied the SAVA syndemic framework;[40,44-47,50] however, psychosocial and structural factors are not included as factors of interest in the SAVA syndemic. The present study will extend the SAVA syndemic framework to include psychosocial (e.g., depression, and post-traumatic stress disorder) and structural (e.g., lack of health insurance, concentrated poverty, unstable housing, neighborhood unemployment, and food insecurity) factors in order to provide salient evidence of the multiple and overlapping factors that negatively impact HIV risk and acquisition among Black women living with and without HIV.

There is also limited evidence of the longitudinal associations between structural and psychosocial syndemic effects on sexual risk behaviors among Black

women and how these associations change over time. The most recent study used data from the HIV Vaccine Trials Network (HVTN) 906 cohort study to investigate longitudinal associations between HIV sexual risk and syndemic factors among women, in which the authors highlight the multiple manifestations of women living in poor social and economic conditions, however, this analysis was not specific to Black women ,[57] who more than likely experience elevated risk for exposure to poor social and economic conditions. There is also a need to investigate whether the relationship between syndemic effects and sexual risk behaviors are different by HIV status. When assessing whether HIV status served as an effect modifier in this relationship, the authors found no evidence of additive or multiplicative interaction between neighborhood characteristics and HIV status on sexual risk behaviors.[21]

Investigating the longitudinal occurrence of structural and psychosocial syndemic effects and HIV risk among Black women can add to the body of research examining syndemics among Black women and can provide innovative ways to identify and address the systems in place that drive the structural and psychosocial vulnerabilities affecting Black women .

The objective of this research is to examine the longitudinal relationship between psychosocial and structural syndemic effects and sexual risk behaviors among a cohort of Black women living with and without HIV. We seek to:

1. Test whether psychosocial and structural factors are mutually reinforcing

2. Measure relationships between a cumulative psychosocial and structural syndemic and sexual risk behaviors over time, and;
3. Test whether HIV status serves as an effect modifier in the relationships between a cumulative psychosocial and structural syndemic and sexual risk behaviors over time

METHODS

Participants

This study utilized data from the Women's Interagency HIV study (WIHS). The WIHS is a multisite, prospective cohort study of HIV-seropositive and HIV-seronegative cisgender women designed to explore HIV progression in women.[52] WIHS participants were enrolled during 4 waves: 1994–95, 2001–02, 2011–12, and 2013–15, and from 10 study sites (San Francisco/Bay Area, CA; Bronx/ Manhattan, NY; Brooklyn, NY; Washington, DC; Chicago, IL; Chapel Hill, NC; Atlanta, GA; Miami, FL; Birmingham, AL; Jackson, MS).[52] During 6-month follow-up visits, study participants were administered a scripted interview, clinical examinations, and laboratory testing. Study questionnaires are available at https://statepi.jhsph.edu/wihs/wordpress/?page_id=455. Study visits where residential addresses were collected were geocoded to census tracts for WIHS study participants who provided written informed consent.

Study participants were recruited using direct recruitment methods. Study participants in the 1994-1995 cohort recruited family members and friends who met eligibility criteria.[53] Specialty healthcare offices such as infection disease, internal

medicine, and obstetrics and gynecology offices in study sites were also contacted for referrals. Additionally, outreach activities such as contacting HIV community organizations and social service organizations were also conducted.[53] The eligibility criteria for participation in the WIHS study included self-identifying as a woman, being aged between 30 and 55 years at study enrollment, able to complete study visit interviews in English or Spanish every 6 months, and able to travel to and from site clinic and participate in study visits as an outpatient.[75] The inclusion criteria included the following: confirmatory HIV infection; willing to be retested for HIV infection; have never taken HIV antiretroviral medications or have documented start date of highly active antiretroviral therapy (HAART) after January 1, 2008; have documentation of pre-HAART CD4 counts and HIV RNA quantification if have taken HAART; willing and able to have blood drawn; and give consent to have specimens stored in the WIHS national repository.[75] Women who reported perinatally acquired HIV infection, enrolled in the WIHS through another site, HAART started before January 1, 2008, except during pregnancy, and plans to move out of the study area within 12 months were excluded to be study participants.[75]

Beginning in 2013, residential addresses were collected from study participants to be geocoded to census-tract level data in the American Community Survey (ACS). The ACS is a continuous nationwide survey that aims to provide a more statistically accurate picture of the demographic, social, economic, and housing characteristics of the communities we live in.[54] The collection of residential addresses allowed for the creation of neighborhood structural variables. Neighborhood structural variables were created using the ACS 5-year estimates from 2010-2014,

2011-2015, 2012-2016, 2013-2017, 2014-2018, and 2015-2019. Each WIHS visit where participant address information was collected was linked to the 5-year ACS corresponding to the current year of the study visit (i.e., study visits between April 2014-September 2014 were linked to the 2014 ACS 5-year estimates; study visits between April 2015-September 2015 were linked to the 2015 ACS 5-year estimates, etc.).

This analysis utilized data from 960 HIV-positive and 404 HIV-negative were non-Hispanic cisgender Black women who participated in WIHS beginning at study visit 39 (January 2013 through January 2020), who had at least one additional study visit after enrollment and provided written consent for residential addresses to be geocoded.

Measures

Outcome Variables

Outcomes included inconsistent condom use, unknown HIV status of last male sex partners, and multiple sex partners in the last 6 months. Each variable was coded with the binary coding structure of 1=Yes and 0=No.

Inconsistent condom use was derived from two measures asking participants how often the participant or their partners wore a condom during vaginal sex since the last study visit and how often the participant's partners wore a condom during anal sex since the last study visit. Responses included "Always," "Sometimes," "Never." Inconsistent condom use was coded as 1=Yes if participants responded "Sometimes" to either question. All other responses were coded as 0=No.

Unknown HIV status of last male sex partners was derived from a question asking if participants knew the HIV serostatus of her partners since the last study. Participant responses indicating that she did not know the HIV serostatus of any of her partners, then her response was recoded as 1=Yes for unknown HIV status of last male sex partners; all other responses were coded 0=No.

Multiple sex partners was assessed by asking participants, "How many men have you had sex with since the last study visit?" Responses indicating two or more male sexual partners were coded as 1=Yes and responses indicating 0 or 1 male sexual partner was coded as 0=No.

Independent Variables

Psychosocial Variables

History of intimate partner abuse was assessed by the responses to two questions asking whether participants ever experienced physical harm by an intimate partner/spouse/boyfriend/girlfriend and whether participants were ever pressured or forced to have sexual contact by an intimate partner/spouse/boyfriend/girlfriend. If participants responded "Yes" to either question, intimate partner abuse was coded as 1=Yes. If participants responded "No" to both questions, intimate partner abuse was coded as 0=No.

History of childhood sexual abuse was derived by a question asking participants whether they have ever been pressured or forced to have sexual contact with anyone before the age of 18 years. Responses indicating "Yes" were coded as 1=Yes and "No" responses were coded as 0=No.

Depressive symptoms was measured using the 20-item Center for Epidemiologic Studies Depression scale (CES-D).[63] The CES-D scale has been used in previous studies that assess depression among Black women .[64] The standard clinical score ≥ 16 was indicative of depressive symptoms and coded 1=Yes; a CES-D score of < 16 was coded 0=No.

High severity of PTSD symptoms was assessed using the 17-item PTSD Checklist-Civilian version, a self-report measure of the DSM-IV.[76] Total scores from the PTSD Checklist-Civilian version ranges from 17-85. In WIHS, the PTSD variable was categorized as: Little to Some PTSD symptoms (indicative of a 17-29 PTSD score); Moderate or Moderately High severity of PTSD (indicative of a PTSD score of 30-44); and High Severity of PTSD (indicative of a PTSD score of 45-85). High severity of PTSD was dichotomized with a PTSD score ≥ 45 coded 1= Yes and a PTSD score of < 45 coded 0= No.

High perceived stress was measured using the 10-item perceived stress scale (PSS-10). The PSS-10 assesses how often a variety of situations have made the respondent feel.[77] Scores from the PSS-10 ranges from 0-40. A score ranging from 0-13 is indicative of low stress; a score of 14-26 is indicative of moderate stress; and a score ranging from 27-40 is indicative of high perceived stress.[77] In this analysis, high perceived stress was dichotomized with a score ≥ 27 coded as 1=Yes and a score of <27 coded as 0=No. In WIHS, data on PTSD and perceived stress was collected as part of the Neurocognition Sub-study for which PTSD and perceived stress data was collected once over 4 study visits. Therefore each 4-visit range of study visits accounts for 1-time point for PTSD and perceived stress data. Using this 4-visit time

point, PTSD and stress data was imputed for study visits for which no PTSD and stress data was reported.

Heavy alcohol use was measured by asking WIHS participants about the average number of days per week that a drink of alcohol was consumed since the last study visit. Study participants were also asked about the usual number of drinks consumed per day since last study visit. The number of drinks per week was calculated by multiplying the reported quantity by the reported frequency per week. In this analysis, heavy alcohol use refers to the consumption of 7 or greater drinks per week. This aligns with heavy alcohol consumption limits specified by the National Institute on Alcohol Abuse and Alcoholism.[78] Heavy alcohol use will be dichotomized where participants who indicated ≥ 7 drinks per week were coded 1=Yes and < 7 drinks per week were coded as 0=No.

Illicit drug use was assessed by asking "Since the last study visit, have you used cocaine, crack, heroin, methamphetamine, hallucinogens, club drugs, or any other illicit or recreational drugs?" Responses were coded as 1=Yes and 0=No.

Participant-level Structural Variables

Lack of health insurance was assessed by asking participants if they had insurance at each study visit, in which responses were classified into four categories derived from the Kaiser Family Foundation: Medicaid, private or student, Medicare or other public health insurance, and no health insurance. For this analysis, health insurance categories were collapsed into 2 categories: "Has Health Insurance" (0=No) and "Does not Have Health Insurance" (1=Yes).

Incarceration was assessed by asking participants whether they had been incarcerated in a prison or a jail since their last study visit. Responses were coded 1=Yes and 0=No.

Annual household income < $24,000 was captured by asking participants about their annual household income at each study visit. If participants responded with an annual household income of <$24,000 per year, then 1=Yes was coded. If participants responded with an annual household income of ≥ $24,000 per year, then 0=No was coded.

Food insecurity was measured using the 18-item U.S. Household Food Security Survey Module (HFSSM).[79] Previous studies that have used the HFSSM have found that the survey accurately identifies food insecurity in households and has found food insecurity to be associated with multiple health outcomes including HIV.[13,80-82] The items in the HFSSM demonstrated high internal consistency reliability (Cronbach's alpha = 0.82).The standard HFSSM scoring system was used to identify participants as having high food security (score of 0), marginal food security (score of 1-2), low food security (score of 3-7), and very low food security (score of 8-18).[79] In this study, low and very low food security was indicative of food insecurity and thus was coded as 1=Yes if the HFSSM score was ≥ 3 and 0=No if the HFSSM score was 0-2.

Unstable housing was coded as 1= Yes if the participant reported living in a shelter, jail, residential treatment center, an "other" place, or on the street and coded 0=No if participants reported living in their own house/apartment, parent's house, or someone else's house/apartment.

Neighborhood-level Structural Variables

Residential addresses from WIHS study participants who provided informed consent were collected starting in 2014. Addresses were geocoded and assigned a corresponding Federal Information Processing Standard (FIPS) code to be linked to census tract level data from six versions of the ACS 5-year estimates. Residential addresses were collected at even-numbered visits (i.e., one of the two semiannual study visits). Because of this, neighborhood-level structural data from even-numbered study visits were used to impute values for the consecutive odd-numbered study visits (i.e., the study visit for which residential addresses were not collected).

ACS 5-year estimates for 2010-2014, 2011-2015, 2012-2016, 2013-2017, 2014-2018, and 2015-2019 were used to derive the neighborhood-level structural variables: concentrated rental cost burdened households, neighborhood unemployment, concentrated poverty, neighborhood low educational attainment, concentrated housing vacancy, neighborhood black racial concentration, and concentrated income inequality. In this analysis, each variable was dichotomized to 1=Yes and 0=No.

Concentrated rental cost burdened households were operationalized as living in a census tract where 50% or more of residents are paying 30% or more of income on rent.

Neighborhood unemployment was defined as living in a census tract where the percent of unemployed civilians, 16 years and older, is greater than 15%.

Concentrated poverty was operationalized as living in a census tract where 25% or more of residents are living below the federal poverty level.

Neighborhood low educational attainment was defined as living in a census tract where 25% or more of residents had less than a high school diploma.

Concentrated housing vacancy was defined as living in a census tract where 15% or more of vacant residential housing units are present.

Neighborhood black racial concentration was defined as living in a census tract where 50% or more of residents were black/African American. Neighborhood black racial concentration was used a proxy for black racial segregation.[69]

Concentrated income inequality was defined as living in a census tract with a Gini coefficient of 0.44. Gini coefficients range from 0 to 1, with 0 indicating complete equality and 1 indicating complete inequality. High income inequality has been identified as 0.44.[69]

Effect Modifier Variable

The moderator of interest is HIV status. In this study, HIV status was coded as 1=HIV-positive and 0=HIV-negative.

Syndemic Parameterizations

Three syndemic parameterizations were applied in this analysis to be longitudinally assessed with sexual risk behaviors. First, a cumulative syndemic index, ranging from 0-19, was created by summing all psychosocial and structural variables. All responses for psychosocial and structural variables had a binary coding

structure of 1= Yes and 0 = No. This binary coding structure made it so that no one factor was worth more than the others. Second, the psychosocial and structural syndemic factors were categorized into three syndemic groups reflecting the level of influence: the psychosocial syndemic group included history of intimate partner abuse, history of childhood sexual abuse, depressive symptoms, high severity of PTSD symptoms, high perceived stress, illicit drug use, and heavy alcohol use; the participant-level structural syndemic group included incarceration, annual household income less than $24,000, lack of health insurance, unstable housing, and food insecurity; and the neighborhood-level structural syndemic group included concentrated rental-burdened households, neighborhood unemployment, neighborhood low educational attainment, concentrated housing vacancy, neighborhood black racial concentration, concentrated poverty, and concentrated income inequality. Groups were treated as continuous variables; therefore, each group represents group-specific cumulative syndemic indices. Lastly, exposure to none, one, two, or three syndemic groups was examined.

Statistical Analysis

Frequencies and percentages summarized the distribution of all psychosocial and structural variables, number of syndemic groups, and sexual risk behaviors reported at baseline for the total study sample and stratified by HIV status. Means and standard deviations were calculated for the mean cumulative syndemic score, as well as individual mean syndemic group scores at baseline for the total study sample and stratified by HIV status. To test differences between HIV-positive and HIV-negative Black women in the analysis, Chi-square tests were conducted to test the differences

in proportions of all categorical variables reported at baseline; and two-sample t-tests were conducted to test the differences in means for continuous variables. Unadjusted generalized estimating equations (GEE) models with the logit link function were conducted to test the associations between each psychosocial and structural factor to determine whether associations were mutually enhancing; thereby providing evidence of a syndemic.

To test for longitudinal effects of syndemic parameterizations on sexual risk behaviors, a series of generalized linear mixed models with the logit link function and random effect for slope and intercept were conducted. Trajectory effects of syndemic parameterization on sexual risk behaviors were included in the models by including an interaction term (e.g., cumulative syndemic count*time). To test whether HIV status was an effect modifier, three-way multiplicative interaction terms (syndemic parametrization*HIV status*time) were included in a series of models for each syndemic parameterization and sexual risk behavior, controlling for study participant's age, education level, and employment status. Interaction terms with $p<0.05$ were considered to be statistically significant. If the interaction terms were not statistically significant then HIV status was included in adjusted models as a potential confounder.

Unadjusted and adjusted generalized linear mixed models were run to estimate odds ratios measuring the longitudinal relationships of syndemic parameterizations on each sexual risk behavior outcome. Covariates including study participant's age, education level, employment status, and potentially, HIV status was controlled for in adjusted models. These covariates were chosen *a priori* based on previous literature

that included these potential confounders in models evaluating sexual risk behavior outcomes. Outliers were assessed by measuring Cook's distance, leverages, and studentized residuals; there was no evidence of overly influential observations. Variance inflation and multicollinearity were assessed by measuring the variance inflation factor (VIF) values; results indicated that there was no evidence of variance inflation (VIF > 5). Additionally, all models utilized complete case analysis.

For all models, maximum likelihood of model parameters were based on the Laplace approximation. Unadjusted and adjusted odds ratios (OR) and 95% confidence intervals were reported; as well as F-statistics and p-values for assessing the interaction effect of HIV status on syndemic parameterizations. All analyses were performed using SAS Studio (SAS Institute, Inc., Cary, NC).

RESULTS

Baseline Psychosocial and Structural Variables and HIV Risk Behavior Outcomes

A total of 1,364 Black women , over 12 study visits were included in this analysis. Of those, 960 were HIV-positive and 404 were HIV-negative. In the analytic sample, most women reported an annual household income <$24,000 (71.6%) at baseline. In terms of neighborhood-level structural variables, most of the sample reported living in census tracts with: concentrated rental burdened households (64.6%), neighborhood black racial segregation (57.8%), and concentrated income inequality (62.5%). Sixteen percent of women reported inconsistent condom, 8.9% reported unknown HIV status of last sexual partners, and 12.7% reported multiple sex

partners since last visit. On average, Black women in this analysis had a cumulative syndemic score of 6 (M=5.5, SD=2.6). On average, the sample had a psychosocial syndemic group score and participant-level group score of 1 (M=1.3, SD=1.3 and M=1.1, SD=0.8, respectively) and a neighborhood-level syndemic group score of 3 (M=3.2, SD=1.8) (Table1).

When stratified by HIV status, HIV-positive women were more likely to report unknown HIV status of last sexual partners compared to HIV-negative women (9.5 vs 7.7, $p<0.05$). In contrast, HIV-negative women reported more multiple sex partners compared with HIV-positive (17.6 vs 10.6, $p<0.05$). HIV-negative women reported more high severity of PTSD symptoms (19.3% vs 17.4%), high perceived stress (4.7% vs 4.3%), heavy alcohol use (18.1% vs 10.3%), no health insurance (17.1% vs 4.4%), and living in census tracts with: concentrated rental burdened households (68.6% vs 62.9%) and neighborhood unemployment (38.6% vs 31.7%; $p<0.05$) compared with their HIV-positive counterparts. Mean cumulative syndemic score and psychosocial syndemic group score was significantly different between HIV-positive and HIV-negative Black women (Table 1).

At baseline, many of the psychosocial and structural variables were significantly associated with each other. Neighborhood-level measures were all associated with each other. Additionally, high severity of PTSD symptoms was strongly associated with high perceived stress (aOR=5.29, 95% CI: 4.53-6.17). Illicit drug use was strongly associated with incarceration (aOR=5.21, 95% CI: 3.23-8.43). Incarceration had a strong association with unstable housing (aOR=4.38, 95% CI: 1.33-14.37) and concentrated housing vacancy (OR=5.79, 95% CI: 2.26-14.83).

There were strong associations observed between unstable housing and annual household income <$24,000 (OR=7.39, 95% CI: 1.80-30.28) (Table 2).

Longitudinal Analyses of Inconsistent Condom Use and Syndemic Parameterizations

Cumulative syndemic score was significantly associated with reporting inconsistent condom use ($F=4.42$, $p<0.05$), however trajectories of cumulative syndemic score, psychosocial syndemic group score, participant-level syndemic group score, neighborhood-level structural syndemic group score, and exposure to syndemic groups did not differ by HIV status ($p> 0.05$, Table 3a-e). When adjusting for age, education level, employment status, and HIV status, being in all three syndemic groups was associated with higher odds of reporting inconsistent condom over time (aOR= 2.15, 95% CI: 1.28-3.61; Table 4). There were no statistically significant observations observed for cumulative syndemic score, psychosocial syndemic group score, participant-level syndemic group score, and neighborhood-level structural syndemic group score (Table 4).

Longitudinal Analyses of Unknown HIV Status of Last Male Sex Partners and Syndemic Parameterizations

Cumulative syndemic score ($F=9.67$, $p<0.05$), psychosocial syndemic group score ($F=4.54$, $p<0.05$), participant-level structural syndemic groups score ($F=9.64$, $p<0.05$), and neighborhood-level structural syndemic group score ($F=3.97$, $p<0.05$) were significantly associated with reporting unknown HIV status of last male sex partners (Table 3a-e). Additionally, trajectories of all syndemic parameterizations did

not differ by HIV status (p> 0.05, Table 3a-e). Being in at least two syndemic groups was associated with higher odds of reporting unknown HIV status of last male sex partners over time (2 groups: aOR=3.04, 95% CI: 1.24-7.44; 3 groups: aOR=5.26, 95% CI: 1.94-14.25; Table 3). There were no statistically significant observations observed for cumulative syndemic score, psychosocial syndemic group score, participant-level syndemic group score, and neighborhood-level structural syndemic group score (Table 4).

Longitudinal Analyses of Multiple Sex Partners and Syndemic Parameterizations

Cumulative syndemic score (F=9.11, p<0.05), psychosocial syndemic group score (F=11.78, p<0.05), participant-level structural syndemic groups score (F=5.76, p<0.05), and number of syndemic group (F=6.55, p<0.05) was significantly associated with reporting multiple sex partners (Table 3a-e). Trajectories of all syndemic parameterizations did not differ by HIV status (p> 0.05, Table 3a-e). Being in two syndemic groups was associated with increased odds of reporting multiple sex partners over time (aOR=4.29, 95% CI: 1.81-10.18; Table 4). Similarly, being in all three syndemic groups was associated with higher odds of reporting multiple sex over time (aOR=7.47, 95% CI: 2.85-19.58; Table 4). There were no statistically significant observations observed for cumulative syndemic score, psychosocial syndemic group score, participant-level syndemic group score, and neighborhood-level structural syndemic group score (Table 4).

DISCUSSION

In this longitudinal study of psychosocial and structural syndemic effects and sexual risk behaviors among Black women living with and without HIV, being in at least 2 syndemic groups was associated with higher odds of reporting inconsistent condom use, unknown HIV status of last male sex partners, and having multiple sex partners. Specifically, a dose-response relationship was observed between number of syndemic groups experienced and reporting multiple sex partners. An interaction effect HIV status was tested; however, findings indicated that associations between the three syndemic parameterizations and sexual risk behaviors did not differ by HIV status. Overall, this analysis provides evidence of persistent effects of syndemic factors occurring on multiple levels that are influencing sexual risk behaviors among a cohort of Black women living with and without HIV.

To our knowledge, only one other study has longitudinally evaluated the association between multilevel syndemic groups and sexual risk behaviors among women in a large cohort study in the United States.[57] Our study findings extend this body of research in four ways. First, our analytic sample consisted of cisgendered non-Hispanic Black women , a population of women that has been systematically excluded from research applying syndemic methodology to sexual risk behaviors. Black women account for 13% of the female population but make up more than half of HIV diagnoses,[1] yet syndemic research is heavily focused on sexual minority populations, specifically men. Therefore, this analysis contributes to the body of syndemic literature with a focus on a priority, underserved population. Secondly, many of the psychosocial and structural variables were associated with each other, indicating evidence of a syndemic. These relationships also illustrate the multiple,

overlapping factors that influence behavior beyond those explored in the SAVA syndemic. SAVA syndemic refers to the synergistic and clustering interrelations of substance abuse, intimate partner abuse, and HIV/AIDS among women living in urban areas in the United States.[40,44-47,50] Despite the robust literature on the SAVA syndemic and its application in women's health research, the SAVA syndemic does not include psychosocial and structural factors such as incarceration, unstable housing, depression, and neighborhood factors (i.e., concentrated poverty, neighborhood unemployment) as units of analysis. Therefore, this study contributes to a more comprehensive syndemic for Black women . Thirdly, the use of three syndemic parameterizations allowed us to disaggregate cumulative syndemic score into groups reflecting the level of influence: psychosocial syndemic group, participant-level syndemic group, and neighborhood-level syndemic group, and categorize number of syndemic groups. The latter allowed us to demonstrate the dose-response relationship between number of syndemic groups and multiple sex partners. Fourth, the longitudinal nature of this analysis allowed for the exploration of syndemic and sexual risk behavior associations over time. There have been few studies on the longitudinal associations of structural and psychosocial syndemic effects on sexual risk behaviors among Black women ; therefore, this analysis contributes to the gap in knowledge.

An important feature to this study is the assessment of neighborhood structural variables as syndemics. Recent research has documented the relationships between neighborhood characteristics and HIV risk among women. In a multilevel study of women in WIHS, the researchers found that greater neighborhood social

disorder, defined by greater violent crime, vacant housing, poverty, and STI prevalence, and social disadvantage, defined by more alcohol outlets and renter-occupied housing, was associated with having a current sexually transmitted infection.[21,22] Furthermore, an ecologic analyses at the county-level found that Black women living with HIV who lived in counties with the lowest quartiles of poverty and health insurance had reduced risk of mortality.[11] Exploring the role of neighborhood-level characteristics and HIV risk is a growing body of research and was instrumental in this study by providing greater context into the overlapping manifestations affecting Black women . Although there were no statistical longitudinal associations observed between neighborhood-level syndemic group score and sexual risk behaviors, neighborhood-level structural syndemic group score was significantly associated with reporting unknown HIV status of last male sex partners. This finding provides evidence of the interplay between how multiple physical (i.e., vacant housing) and social (i.e., rental cost burden, poverty) structures of a neighborhood impact the individuals living in the neighborhood.

Although there were no observed statistical associations between overall syndemic score and sexual risk behaviors over time, most associations were approaching significance. Despite statistical significance, cumulative syndemic score was inversely associated with sexual risk behaviors; that is, the odds of reporting sexual risk behaviors decreased as syndemic score increased over time. This finding is common in many cohort and intervention studies and may reflect bias over time to report lower sexual risk behaviors. Also, there were no observed statistical associations of syndemic group scores and sexual risk behaviors over time; however,

results indicated that being in at least 2 syndemic groups was associated with higher odds of reporting sexual risk behaviors. These findings suggest that the cumulative effect of syndemics by group should not be explored alone but explored in combination with each other to predict sexual risk behavior outcomes. In all, these findings provide evidence that syndemic factors affecting Black women are not unidimensional but rather occurring on multiple levels and intersecting with each other to influence sexual risk behaviors.

This study is not without limitations. First, to create neighborhood-level structural factors, study visits where address information was collected was linked to the 5-year ACS corresponding to the current year of the study visit. This may have resulted in misclassification as the year linked to study visit may not accurately reflect the characteristics of the census tract at time of study visit. The researchers chose to link ACS estimates to the current year of the study visit because the analysis included study visits for which relevant 5-year ACS estimates did not yet exist. Second, the study variables included in this study may not represent the extent of psychosocial, participant-level structural, and neighborhood structural characteristics that impose on Black women ’s risk for HIV. Therefore, further exploration is needed to examine how the inclusion of additional factors in syndemic methodology impacts sexual risk behaviors among Black women . Third, our ability to examine additional sexual risk behaviors outcomes such as exchange sex was limited due to model instability, including failing to converge. Fourth, there was no interaction effect with HIV status observed between the longitudinal association between syndemic effects and sexual risk behaviors. This finding was unexpected however, it is difficult to

observe a statistically significant three-way multiplicative interaction term as was used in this analysis without a large enough sample size. Therefore, it is possible for HIV status to be an effect modifier in longitudinal relationships given the statistically significant associations between syndemic parameterizations and sexual risk behaviors at baseline. Fifth, due to how PTSD and perceived stress measures were collected (data was collected once over 4 study visits), the researchers imputed responses from the 4-visit time point to study visits for which no PTSD and perceived stress data was reported. This could have also resulted in misclassification of high severity of PTSD symptoms and high perceived stress variables because participant's imputed responses for a study visit where no PTSD and perceived stress measures were collected may not reflect the true responses of the participant at that specific time. Finally, self-reported measures were used to collect information on outcome and exposure variables thereby influencing the possibility of bias and misclassification.

CONCLUSION

The study measured the longitudinal effects of psychosocial and structural syndemics on HIV risk among Black women in a large cohort. Although the study is not assessing causality, its longitudinal nature increases the ability to make inferences regarding temporal relationships. The findings from this study contributes to epidemiological literature given there have been few studies investigating the relative impact of psychosocial and structural syndemic effects on sexual risk behaviors in Black women . Additionally, the inclusion of neighborhood characteristics in this syndemic framework highlights how multiple manifestations operating at different

levels greatly impact sexual risk behaviors among Black women . These findings provide context about a large cohort of Black women experiencing multiple poor psychosocial and structural factors; therefore, the need for comprehensive HIV prevention strategies and initiatives are apparent.

Table 1: Syndemic and sexual risk behavior characteristics reported at baseline among Black women in the Women's Interagency HIV Study, Stratified by HIV Status

	Total Sample (N=1364)	**HIV-Positive Black women (N=960)**	**HIV-Negative Black women (N=404)**
Variables Reported since Last Study Visit	**N (%)**	**N (%)**	**N (%)**
Psychosocial Characteristics			
History of Intimate Partner Abuse			
Yes	519 (38.1)	346 (36.0)	173 (42.8)
No	776 (56.9)	564 (58.8)	212 (52.5)
Missing	69 (5.1)	50 (5.2)	19 (4.7)
History of Childhood Sexual Abuse			
Yes	196 (14.4)	132 (13.8)	64 (15.8)
No	1057 (77.5)	748 (77.9)	309 (76.5)
Missing	111 (8.1)	80 (8.3)	31 (7.7)
Depressive Symptoms			
Yes	412 (30.2)	291 (30.3)	121 (30.0)
No	918 (67.3)	644 (67.1)	274 (67.8)
Missing	34 (2.5)	25 (2.6)	9 (2.2)
High Severity of PTSD Symptoms*			

Yes	245 (18.0)	**167 (17.4)**	**78 (19.3)**
No	938 (68.8)	**683 (71.2)**	**255 (63.1)**
Missing	181 (13.3)	**110 (11.5)**	**71 (17.6)**
High Perceived Stress*			
Yes	60 (4.4)	**41 (4.3)**	**19 (4.7)**
No	1122 (82.3)	**809 (84.3)**	**313 (77.5)**
Missing	182 (13.3)	**110 (11.5)**	**72 (17.82)**
Illicit Drug Use			
Yes	130 (9.5)	88 (9.2)	42 (10.4)
No	1206 (88.4)	853 (88.9)	353 (87.4)
Missing	28 (2.1)	19 (2.0)	9 (2.2)
Heavy Alcohol Use*			
Yes	172 (12.6)	**99 (10.3)**	**73 (18.1)**
No	1164 (85.3)	**842 (87.7)**	**322 (79.7)**
Missing	28 (2.1)	**19 (2.0)**	**9 (2.2)**
Structural Factors			
Participant-level Characteristics			
Incarceration			
Yes	21 (1.5)	17 (1.8)	4 (1.0)
No	1316 (96.5)	924 (96.3)	392 (97.0)

Missing	27 (1.5)	19 (2.0)	8 (2.0)
Food Insecurity			
Yes	293 (21.5)	206 (21.5)	87 (21.5)
No	1068 (78.3)	752 (78.3)	316 (78.2)
Missing	3 (0.2)	2 (0.2)	1 (0.3)
Unstable Housing			
Yes	49 (3.6)	34 (3.5)	15 (3.7)
No	1287 (94.4)	906 (94.4)	381 (94.3)
Missing	28 (2.1)	20 (2.1)	8 (2.0)
Health Insurance Status*			
Has Health Insurance	1224 (89.7)	**899 (93.7)**	**325 (80.5)**
Does Not Have Health Insurance	111 (8.1)	**42 (4.4)**	**69 (17.1)**
Missing	29 (2.1)	**19 (2.0)**	**10 (2.5)**
Annual Household Income <$24,000			
Yes	977 (71.6)	700 (72.9)	277 (68.6)
No	314 (23.0)	205 (21.4)	109 (27.0)
Missing	73 (5.4)	55 (5.7)	18 (4.5)
Neighborhood-level Characteristics			
Living in census-tracts with concentrated rental burdened households*			

Yes	881 (64.6)	**604 (62.9)**	**277 (68.6)**
No	483 (35.4)	**356 (37.1)**	**127 (31.4)**
Living in census tracts with neighborhood low educational attainment			
Yes	371 (27.2)	258 (26.9)	113 (28.0)
No	993 (72.8)	702 (73.1)	291 (72.0)
Living in census tracts with neighborhood unemployment*			
Yes	460 (33.7)	**304 (31.7)**	**156 (38.6)**
No	904 (66.3)	**656 (68.3)**	**248 (61.4)**
Living in census tracts with concentrated housing vacancy			
Yes	407 (29.8)	298 (31.0)	109 (27.0)
No	957 (70.2)	662 (67.0)	295 (73.0)
Living in census tracts with neighborhood black racial concentration			
Yes	788 (57.8)	550 (57.3)	238 (58.9)
No	576 (42.2)	410 (42.7)	166 (41.1)
Living in census tracts with concentrated poverty			
Yes	603 (44.2)	421 (43.9)	182 (45.1)
No	761 (55.8)	539 (56.2)	222 (55.0)

Living in census tracts with concentrated income inequality			
Yes	852 (62.5)	597 (62.2)	255 (63.1)
No	512 (37.5)	363 (37.8)	149 (36.9)
Syndemic Parameterizations			
Cumulative Syndemic Score, M (SD)*	5.5 (2.6)	**5.4 (2.6)**	**5.8 (2.8)**
Psychosocial Syndemic Group Score, M (SD)*	1.3 (1.3)	**1.2 (1.2)**	**1.4 (1.3)**
Participant level Syndemic Group Score, M (SD)	1.1 (0.8)	1.0 (0.7)	1.1 (0.9)
Neighborhood-level Syndemic Group Score, M (SD)	3.2 (1.8)	3.2 (1.8)	3.3 (1.9)
Number of Syndemic Groups*			
0	174 (12.8)	**113 (11.8)**	**61 (15.1)**
1	657 (48.2)	**483 (50.3)**	**174 (43.1)**
2	373 (27.4)	**271 (28.2)**	**102 (25.3)**
3	160 (11.7)	**93 (9.7)**	**67 (16.6)**
Sexual Risk Behaviors			
Inconsistent Condom Use			
Yes	213 (15.6)	142 (14.8)	71 (17.6)
No	634 (46.5)	438 (45.6)	196 (48.5)
Missing	517 (37.90)	380 (39.6)	137 (33.9)

Unknown HIV Status of Last Male Sexual Partners*			
Yes	122 (8.9)	**91 (9.5)**	**31 (7.7)**
No	730 (53.5)	**493 (51.4)**	**237 (58.7)**
Missing	512 (37.5)	**376 (39.2)**	**136 (33.7)**
Multiple Sex Partners (2 or more partners) *			
Yes	173 (12.7)	**102 (10.6)**	**71 (17.6)**
No	1162 (85.2)	**838 (87.3)**	**324 (80.2)**
Missing	29 (2.1)	**20 (2.1)**	**9 (2.2)**
***p<0.05**			

Table 2: Bivariate odds ratios between each psychosocial and structural syndemic factor at baseline

	Intimate Partner Violene	History of Sexual Childhood Abuse	Depressive Symptoms	High Severity of PTSD symptoms	High Perceived Stress	Illicit Drug Use	Heavy Alcohol Use	Incarceration	Food Insecurity	Unstable Housing	Annual household income <$24,000	Lack of Health Insurance	Concentrated Rental Cost Burdened	Neighborhood low educational attainment	Neighborhood Unemployment	Concentrated Poverty	Concentrated Housing Vacancy	Neighborhood Black Racial Concentration
Syndemic Variables	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI
History of Childhood Sexual Abuse	**1.87 (1.64-2.13)**	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Depressive Symptoms	**1.33 (1.16-1.53)**	1.19 (0.90-1.56)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
High Severity of PTSD symptoms	**1.27 (1.08-1.49)**	**1.60 (1.19-2.15)**	**3.18 (2.73-3.70)**	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
High Perceived Stress	**1.36 (1.06-1.74)**	**1.65 (1.02-2.64)**	**2.77 (2.35-3.26)**	**5.29 (4.53-6.17)**	—													
Illicit Drug Use	**1.32 (1.09-1.60)**	1.07 (0.70-1.66)	**1.82 (1.51-2.20)**	**1.73 (1.30-2.30)**	**2.34 (1.29-4.28)**	—	—	—	—	—	—	—	—	—	—	—	—	—
Heavy Alcohol Use	1.09 (0.90-1.32)	0.89 (0.59-1.34)	**1.50 (1.24-1.82)**	**1.36 (1.01-1.82)**	1.10 (0.53-2.26)	**3.58 (2.59-4.95)**	—	—	—	—	—	—	—	—	—	—	—	—
Incarceration	**1.73 (1.26-2.36)**	1.44 (0.60-3.45)	**2.19 (1.60-3.00)**	1.60 (0.78-3.30)	1.30 (0.19-8.75)	**5.21 (3.23-8.43)**	**2.65 (1.43-4.94)**	—	—	—	—		—	—	—	—	—	—
Food Insecurity	**1.35 (1.18-1.56)**	1.31 (0.98-1.75)	**2.02 (1.74-2.36)**	**2.14 (1.72-2.67)**	**2.40 (1.45-3.96)**	**2.48 (1.79-3.43)**	**1.52 (1.12-2.05)**	**3.28 (1.41-7.64)**	—	—	—	—	—	—	—	—	—	—
Unstable Housing	1.18 (0.86-1.61)	1.27 (0.70-2.32)	**1.98 (1.54-2.53)**	**2.16 (1.48-3.14)**	1.51 (0.50-4.62)	**2.91 (1.77-4.79)**	1.45 (0.79-2.66)	**4.38 (1.33-14.37)**	**2.15 (1.55-2.99)**	—	—	—	—	—	—	—	—	—
Annual household income <$24,000	**1.25 (1.05-1.49)**	1.28 (0.92-1.78)	**1.81 (1.42-2.31)**	**1.82 (1.31-2.53)**	1.56 (0.80-3.04)	**2.62 (1.53-4.50)**	**1.93 (1.28-2.92)**	1.82 (0.54-6.17)	**1.68 (1.26-2.25)**	**7.39 (1.80-30.28)**	—	—	—	—	—	—	—	—
Lack of Heath Insurance	0.99 (0.77-1.27)	0.85 (0.51-1.44)	**1.41 (1.12-1.78)**	**1.73 (1.26-2.38)**	0.92 (0.34-2.46)	**2.27 (1.50-3.44)**	**1.88 (1.29-2.73)**	2.59 (0.89-7.57)	**1.63 (1.23-2.17)**	**2.15 (1.03-4.47)**	1.00 (0.90-1.13)	—	—	—	—	—	—	—
Concentrated Rental cost burdened	1.12 (0.97-1.30)	0.88 (0.66-1.12)	1.16 (0.98-1.38)	**1.44 (1.12-1.86)**	1.30 (0.76-2.22)	0.98 (0.70-1.39)	**1.48 (1.07-2.03)**	1.73 (0.64-4.71)	1.14 (0.92-1.42)	1.50 (0.81-2.81)	**1.08 (1.01-1.16)**	1.17 (0.80-1.72)	—	—	—	—	—	—
Neighborhood low educational attainment	**1.17 (1.01-1.35)**	**0.72 (0.53-0.99)**	0.90 (0.74-1.08)	1.08 (0.85-1.38)	1.13 (0.66-1.94)	1.02 (0.70-1.46)	1.03 (0.75-1.40)	0.44 (0.13-1.49)	0.95 (0.76-1.20)	**0.44 (0.20-0.97)**	**1.14 (1.08-1.22)**	0.81 (0.53-1.24)	**1.35 (1.25-1.45)**	—	—	—	—	—
Neighborhood Unemployment	1.14 (1.00-1.31)	0.90 (0.68-1.19)	1.16 (0.98-1.37)	1.04 (0.82-1.32)	0.96 (0.56-1.63)	1.34 (0.96-1.87)	**1.44 (1.09-1.90)**	2.15 (0.92-5.03)	1.23 (1.00-1.51)	0.78 (0.43-1.44)	**1.13 (1.06-1.20)**	**1.49 (1.04-2.13)**	**1.28 (1.18-1.38)**	**1.91 (1.61-2.27)**	—	—	—	—
Concentrated Poverty	1.13 (0.99-1.29)	0.86 (0.67-1.12)	1.01 (0.86-1.19)	1.02 (0.81-1.27)	0.59 (0.35-1.00)	1.33 (0.96-1.84)	**1.37 (1.04-1.81)**	1.14 (0.49-2.67)	0.91 (0.74-1.12)	1.02 (0.59-1.77)	**1.23 (1.16-1.31)**	1.27 (0.89-1.82)	**1.40 (1.30-1.52)**	**4.31 (3.47-5.36)**	**3.38 (2.84-4.03)**	—	—	—
Concentrated Housing Vacancy	0.99 (0.86-1.15)	0.89 (0.67-1.20)	**1.35 (1.15-1.59)**	**1.43 (1.14-1.79)**	1.14 (0.67-1.93)	**1.92 (1.39-2.66)**	**1.37 (1.03-1.83)**	**5.79 (2.26-14.83)**	**1.27 (1.03-1.57)**	**2.05 (1.18-3.55)**	**1.21 (1.14-1.28)**	**2.11 (1.48-3.01)**	**1.20 (1.11-1.30)**	**0.80 (0.65-0.98)**	**2.27 (1.97-2.62)**	**1.77 (1.58-1.98)**	—	—
Neighborhood Black Racial concentration	**0.86 (0.75-0.98)**	0.80 (0.62-1.03)	0.97 (0.83-1.14)	0.86 (0.69-1.08)	0.97 (0.59-1.59)	1.24 (0.88-1.74)	1.14 (0.85-1.52)	2.33 (0.86-6.34)	1.16 (0.94-1.43)	1.15 (0.65-2.02)	1.02 (0.96-1.09)	**1.79 (1.21-2.67)**	**1.31 (1.20-1.43)**	**0.63 (0.53-0.75)**	**3.42 (2.76-4.24)**	**1.43 (1.26-1.63)**	**3.52 (2.79-4.45)**	—
Concentrated Income Inequality	**1.23 (1.07-1.42)**	0.87 (0.67-1.12)	1.02 (0.86-1.20)	0.94 (0.75-1.18)	0.73 (0.44-1.19)	1.21 (0.85-1.71)	**1.55 (1.13-2.12)**	0.97 (0.41-2.33)	1.05 (0.85-1.29)	1.12 (0.63-2.00)	**1.21 (1.13-1.30)**	0.73 (0.51-1.04)	**1.14 (1.05-1.24)**	**1.56 (1.28-1.91)**	**1.53 (1.29-1.81)**	**2.99 (2.49-3.59)**	**1.36 (1.13-1.62)**	**1.12 (1.02-1.24)**

*Estimates where p<0.05 are bolded to facilitate interpretation

Table 3a: Analysis of interaction effect of HIV status on the trajectory of cumulative syndemic score (cumulative syndemic score*time*HIV status) on sexual risk behaviors

	Inconsistent Condom Use		Unknown HIV status of last male sex partners		Multiple Sex Partners	
Variables	F-Statistic	P	F-Statistic	P	F-Statistic	P
Cumulative Syndemic Score	**4.42**	**0.0357**	**9.67**	**0.0019**	**9.11**	**0.0025**
Time	0.41	0.5203	0.01	0.9345	**4.93**	**0.0266**
HIV Status	0.05	0.8268	3.16	0.0755	**10.2**	**0.0014**
Cumulative Syndemic Score*Time	0.63	0.4261	0.39	0.5343	0.15	0.7025
Cumulative Syndemic Score*HIV Status	0.05	0.8306	1.28	0.2576	**4.50**	**0.0339**
HIV Status*Time	0	0.9995	0.1	0.7501	0.11	0.7446
Cumulative Syndemic Score*Time*HIV Status	0.01	0.9170	0.08	0.7805	1.23	0.2672
F-statistics are adjusted for age at visit, education level, and employment status F-statistics where p<.05 are bolded to facilitate interpretation.						

Table 3b: Analysis of interaction effect of HIV status on the trajectory of psychosocial syndemic group score (psychosocial syndemic group score*time*HIV status) on sexual risk behaviors

	Inconsistent Condom Use		Unknown HIV status of last male sex partners		Multiple Sex Partners	
Variables	F-Statistic	P	F-Statistic	P	F-Statistic	P
Psychosocial Syndemic Group Score	**5.49**	**0.0192**	**4.54**	**0.0331**	**11.78**	**0.0006**
Time	1.97	0.1603	1.06	0.3027	**6.33**	**0.012**
HIV Status	0.79	0.3736	1.72	0.1900	**9.78**	**0.0018**
Psychosocial Syndemic Group Score*Time	1.41	0.2350	0.01	0.9388	0.45	0.5016
Psychosocial Syndemic Group Score* HIV Status	0.06	0.8126	0.16	0.6904	2.94	0.0864
HIV Status*Time	0.01	0.9046	0.07	0.7963	1.15	0.2829
Psychosocial Syndemic Group Score*Time*HIV Status	0.02	0.8951	0.27	0.6030	0.13	0.7164
F-statistics are adjusted for age at visit, education level, and employment status F-statistics where p<.05 are bolded to facilitate interpretation.						

Table 3c: Analysis of interaction effect of HIV status on the trajectory of participant-level structural syndemic group score (participant-level structural syndemic group score*time*HIV status) on sexual risk behaviors

	Inconsistent Condom Use		Unknown HIV status of last male sex partners		Multiple Sex Partners	
Variables	F-Statistic	P	F-Statistic	P	F-Statistic	P
Participant-level Structural Syndemic Group Score	0.32	0.5703	**9.64**	**0.0019**	**5.76**	**0.0164**
Time	3.36	0.0671	0.01	0.9248	**7.97**	**0.0048**
HIV Status	3.73	0.0535	**5.4**	**0.0202**	**5.55**	**0.0185**
Participant-level Structural Syndemic Group Score*Time	0.05	0.8160	1.54	0.2149	0.11	0.7422
Participant-level Structural Syndemic Group Score*HIV Status	2.5	0.1141	1.57	0.2100	0.54	0.4634
HIV Status*Time	1.21	0.2720	1.13	0.2884	0.13	0.7193
Participant-level Structural Syndemic Group Score*Time*HIV Status	1.12	0.2890	0.04	0.8324	1.19	0.2754
F-statistics are adjusted for age at visit, education level, and employment status F-statistics where p<.05 are bolded to facilitate interpretation.						

Table 3d: Analysis of interaction effect of HIV status on the trajectory of neighborhood-level structural syndemic group score (neighborhood-level structural syndemic group score*time*HIV status) on sexual risk behaviors

	Inconsistent Condom Use		Unknown HIV status of last male sex partners		Multiple Sex Partners	
Variables	F-Statistic	P	F-Statistic	P	F-Statistic	P
Neighborhood-level Structural Syndemic Group Score	1.02	0.3133	**3.97**	**0.0464**	0.38	0.5403
Time	1.98	0.1596	0.00	0.9811	**6.51**	**0.0108**
HIV Status	0.06	0.8089	3.22	0.0727	3.2	0.0737
Neighborhood-level Structural Syndemic Group Score*Time	0.04	0.8515	0.6	0.4383	0.17	0.6790
Neighborhood-level Structural Syndemic Group Score *HIV Status	1.07	0.3012	0.98	0.3230	0.16	0.6858
HIV Status*Time	0.03	0.8535	0.7	0.4035	0.85	0.3560
Neighborhood-level Structural Syndemic Group Score*Time *HIV Status	0.11	0.7401	0.02	0.9006	0.05	0.8283
F-statistics are adjusted for age at visit, education level, and employment status F-statistics where $p<.05$ are bolded to facilitate interpretation.						

Table 3e: Analysis of interaction effect of HIV status on the trajectory of Syndemic Group Number (number of syndemic groups*time*HIV status) on sexual risk behaviors

	Inconsistent Condom Use		Unknown HIV status of last male sex partners		Multiple Sex Partners	
Variables	F-Statistic	P	F-Statistic	P	F-Statistic	P
Number of Syndemic Groups	1.36	0.2534	2.56	0.0534	**6.55**	**0.0002**
Time	**9.75**	**0.0018**	1.30	0.2548	**12.22**	**0.0005**
HIV Status	0.58	0.4464	1.11	0.2920	**5.64**	**0.0175**
Number of Syndemic Groups*Time	0.57	0.6340	0.87	0.4561	0.82	0.4846
Number of Syndemic Groups*HIV Status	0.22	0.8816	0.78	0.5044	0.48	0.6969
HIV Status*Time	0.13	0.7184	0.60	0.4370	2.39	0.1225
Number of Syndemic Groups*Time*HIV Status	0.57	0.6376	0.22	0.8802	0.32	0.8095
F-statistics are adjusted for age at visit, education level, and employment status F-statistics where p<.05 are bolded to facilitate interpretation.						

Table 4: Longitudinal analyses of the associations between syndemic factors and sexual risk behavior outcomes among Black women

	Inconsistent Condom Use (N= 847)		Unknown HIV status of last male sex partners (N=852)		Multiple Sex Partners (N=1,335)	
Syndemic Variables	OR (95% CI)	aOR (95% CI)	OR (95% CI)	aOR (95% CI)	OR (95% CI)	aOR (95% CI)
Cumulative Syndemic Score	0.99 (0.97-1.01)	0.99 (0.97-1.01)	0.98 (0.93-1.02)	0.98 (0.93-1.02)	0.99 (0.95-1.03)	0.99 (0.95-1.02)
Psychosocial Syndemic Group Score	0.97 (0.93-1.00)	0.97 (0.93-1.00)	0.98 (0.89-1.07)	0.97 (0.89-1.06)	0.95 (0.88-1.02)	0.95 (0.88-1.01)
Participant-level Structural Syndemic Group Score	0.96 (0.90-1.02)	0.96 (0.90-1.01)	0.92 (0.79-1.06)	0.91 (0.79-1.06)	0.97 (0.86-1.09)	0.96 (0.86-1.08)
Neighborhood-level Structural Syndemic Group Score	1.00 (0.98-1.03)	1.00 (0.98-1.03)	0.98 (0.92-1.04)	0.98 (0.92-1.05)	1.01 (0.95-1.07)	1.00 (0.95-1.06)
Number of Syndemic Groups						
0	REF	REF	REF	REF	REF	REF
1	1.22 (0.83-1.79)	1.13 (0.77-1.66)	1.96 (0.68-5.61)	2.55 (0.83-7.80)	0.99 (0.42-2.32)	1.24 (0.55-2.77)
2	1.37 (0.89-2.11)	1.21 (0.78-1.89)	**6.12 (2.02-18.52)**	**8.25 (2.53-26.90)**	**3.04 (1.24-7.44)**	**4.29 (1.81-10.18)**
3	**2.52 (1.52-4.17)**	**2.15 (1.28-3.61)**	**4.32 (1.21-15.46)**	**6.19 (1.62-23.65)**	**5.26 (1.94-14.25)**	**7.47 (2.85-19.58)**

*Estimates where p<.05 are bolded to facilitate interpretation.
*Adjusted models are controlled for study participant's age, education level, employment status, and HIV status
*Five models were fit for each outcome: one with cumulative syndemic score, one with psychosocial syndemic group score, one with participant-level structural syndemic group score, one with neighborhood-level syndemic group score, and one with syndemic group number

Chapter 5: Exploring a Longitudinal Syndemic Effect of Psychosocial and Structural Factors on HIV-related Outcomes among Black women Living with HIV (Manuscript 3)

Abstract

Syndemic effects have been found to be associated with HIV treatment and care outcomes, yet limited research has explored the longitudinal role of psychosocial and structural syndemic effects on HIV care outcomes among HIV-positive Black women . To fill this gap, we conducted a longitudinal analysis using data from 969 HIV-positive Black women in the Women's Interagency HIV Study. Three groups of variables, psychosocial, participant-level structural, and neighborhood-level structural were assessed as cumulative syndemic effects and group syndemic effects. A series of generalized linear mixed models were conducted to measure trajectory effects of psychosocial and structural syndemics on HIV care outcomes, including sub-optimal HIV medication adherence, missed HIV appointments, and sub-optimal healthcare utilization. A higher cumulative syndemic score (OR=1.04, 95% CI: 1.01-1.06) and a higher neighborhood-level structural syndemic group score (OR=1.04, 95% CI: 1.01-1.08) was associated with increased odds of reporting sub-optimal HIV medication adherence. Black women in two syndemic groups had increased odds of reporting sub-optimal HIV medication adherence (OR=2.16, 95% CI: 1.10-4.23). Black women in all three syndemic groups had increased odds of reporting sub-optimal HIV medication adherence (OR=2.88, 95% CI: 1.32-6.29) and missed HIV appointments (OR=3.39, 95% CI: 1.06-10.92). Results from our study highlight the clustering effects of psychosocial and structural factors that influence HIV care outcome among

a cohort of HIV-positive Black women and suggest the need of interventions that address psychosocial and structural factors operating on multiple levels that exacerbate negative HIV care and treatment outcomes.

INTRODUCTION

Improving the health of individuals living with HIV is critical in not only controlling onward transmission of HIV, but also increasing positive quality-of-life outcomes. In 2018, there were 141,754 Black women living with diagnosed HIV in the United States, representing 59% of all women living with diagnosed HIV.[2] It is critically important for people living with HIV (PLWH) to engage in the HIV care continuum in order to achieve long-term health and wellness. However, there is evidence that shows that black men and women living with HIV are less likely to be linked to medical care.[83] This finding has important implications to HIV medication adherence and viral suppression. If a PLWH is not adequately linked to care, medication adherence, and viral suppression are nearly impossible. Viral suppression can be achieved and maintained only when an individual routinely engages in HIV care and adheres to antiretroviral medications. Furthermore, optimal HIV care engagement and medication adherence is critical in reducing HIV transmission, HIV progression to AIDS, and death due to HIV-related complications.[84] Despite knowledge of these critical aspects of engagement in the HIV continuum of care, Black women living with HIV continue to be less likely to be engaged and virally suppressed.[85]

Prior studies have identified psychosocial factors that have an influence on medication adherence, particularly among women living with HIV. Extant literature has shown an inverse relationship between histories of trauma and abuse and medication adherence among women living with HIV--that is, women living with HIV who also have a history of trauma and abuse are less likely to adhere to HIV

medications.[86-88] Trauma and abuse rates have been found to be disproportionately higher among women living with HIV compared to those who are not. Findings from a meta-analysis indicated that the rate of intimate partner violence among women with HIV to be 55%, a rate almost two times higher than the US national average of 33%.[89,90] Similarly, experiences of racism and discrimination have been found to be higher among Black women , compared to women of other racial ethnic groups. The Black women 's Health study, a longitudinal study aimed at exploring the causes of myriad diseases and the determinants that affect them among Black women , reported that 66% of study participants reported lifetime exposure to one or more types of discrimination including on the job, in housing, by the police.[91] Among individuals living with HIV, racial discrimination has been linked to non-adherence to HIV medication.[92,93] Additionally, a study exploring the relationship between critical consciousness, which includes the awareness that social oppression and discrimination exists, and HIV disease markers indicated that for Black women , high critical consciousness was associated with having high CD4+ counts and low detectable viral loads, which also have important implications for HIV medication adherence and HIV-related outcomes.[94]

There is robust literature on the relationships between psychosocial factors and HIV care; however, there is limited data on how structural factors influence HIV care outcomes, including medication adherence and HIV care engagement. Structural factors such as economic disadvantage, housing insecurity, neighborhood disorder, and food instability have explored their independent associations with HIV medication adherence; however, the findings have been mixed and inconsistent.[95-100]

Given this gap in the current knowledge, investigating the psychosocial and structural factors influencing HIV-related outcomes is critical in effectively addressing drivers of HIV disparities among Black women . Furthermore, little is known about how these factors may create a syndemic that influences HIV-related outcomes such as HIV medication adherence and HIV care engagement.

This study will apply syndemic theory to explore the syndemic effects of psychosocial and structural factors on HIV care outcomes among Black women over time. Syndemic theory proposes that multiple, co-occurring factors converge and have a cumulative effect on the excess burden of disease.[42,43,49] These syndemic factors are not only operating on the level of the individual, but on multiple levels including neighborhood and societal--making the exploration of syndemic factors a complex one. Syndemic theory has been applied in health research to explore the synergistic effect of multiple, co-occurring factors on disease risk. The clustering effects of substance abuse, violence, and HIV/AIDS is referred to as the SAVA syndemic and has been applied to women living with HIV. In a study exploring the SAVA syndemic and HIV viral suppression among women of color, the cumulative effect of substance abuse, binge drinking, intimate partner abuse, and poor mental health was associated with having detectable viral loads.[40] There have been few studies that have extended the SAVA syndemic to include additional psychosocial and structural factors when investigating HIV care outcomes such as HIV medication adherence and HIV care engagement.

The longitudinal data in the Women's Interagency HIV study (WIHS) allows for the assessment of the relationship between psychosocial and structural syndemic

effects and HIV care outcomes. The present study aims to fill in the gaps in literature by longitudinally exploring psychosocial and structural syndemic effects on HIV medication adherence, missed HIV appointments, and healthcare utilization among Black women living with diagnosed HIV in the WIHS.

METHODS

Participants

The Women's Interagency HIV Study (WIHS) is a multisite, prospective cohort study of HIV-seropositive and HIV-seronegative cisgender women designed to explore HIV progression in women.[52] WIHS participants were enrolled during 4 waves: 1994–95, 2001–02, 2011–12, and 2013–15, and from 10 study sites (San Francisco/Bay Area, CA; Bronx/ Manhattan, NY; Brooklyn, NY; Washington, DC; Chicago, IL; Chapel Hill, NC; Atlanta, GA; Miami, FL; Birmingham, AL; Jackson, MS).[53] During 6-month follow-up visits, WIHS study participants completed a scripted interview, clinical examinations, and laboratory testing. Study questionnaires are available at https://statepi.jhsph.edu/wihs/wordpress/?page_id=455. Study visits where residential addresses collected were geocoded to census tracts for WIHS study participants who provided written informed consent.

Study participants were recruited using direct recruitment methods. Study participants in the 1994-1995 cohort recruited family members and friends who met eligibility criteria.[74] Specialty healthcare offices such as infectious disease, internal medicine, and obstetrics and gynecology offices in study sites were also contacted for referrals. Additionally, outreach activities such as contacting HIV community

organizations and social service organizations were also conducted.[75] The eligibility criteria for participation in the WIHS study included self-identifying as a woman, being aged between 30 and 55 years at study enrollment, able to complete study visit interviews in English or Spanish every 6 months, and able to travel to and from the site clinic and participate in study visits as an outpatient.[101] The inclusion criteria included the following: confirmatory HIV infection; willing to be retested for HIV infection; have never taken HIV antiretroviral medications or have documented start date of highly active antiretroviral therapy (HAART) after January 1, 2008; have documentation of pre-HAART CD4 counts and HIV RNA quantification if have taken HAART; willing and able to have blood drawn; and give consent to have specimens stored in the WIHS national repository.[101] Women who reported perinatally acquired HIV infection, enrolled in the WIHS through another site, HAART started before January 1, 2008, except during pregnancy, and plans to move out of the study area within 12 months were excluded to be study participants.[101]

Beginning in 2013, residential addresses were collected from study participants to be geocoded to census-tract level data in the American Community Survey (ACS). The ACS is a continuous nationwide survey that aims to provide a more statistically accurate picture of the demographic, social, economic, and housing characteristics of the communities we live in.[54] The collection of residential addresses allowed for the creation of neighborhood structural variables. Neighborhood structural variables were created using the ACS 5-year estimates from 2010-2014, 2011-2015, 2012-2016, 2013-2017, 2014-2018, and 2015-2019. Each WIHS visit where participant address information was collected was linked to the 5-year ACS

corresponding to the current year of the study visit (i.e., study visits between April 2014-September 2014 were linked to the 2014 ACS 5-year estimates; study visits between April 2015-September 2015 were linked to the 2015 ACS 5-year estimates, etc.). This study includes data from HIV-seropositive Black women who participated in WIHS beginning at study visit 39 (January 2013 through January 2020), who had at least one additional study visit after enrollment.

Measures

Outcome Variables:

In this study, the outcomes included sub-optimal HIV medication adherence, missed HIV appointments, and sub-optimal healthcare utilization. Responses to each outcome variable were coded as 1=Yes and 0=No.

Sub-optimal HIV medication adherence was derived from a question asking participants how often antiretrovirals were taken as prescribed over the last six months. Responses ranged from "100% of the time" to "I haven't taken any of my prescribed medications". Responses indicating taking antiretrovirals as prescribed less than 95% of the time was coded as 1=Yes; responses indicating taking antiretrovirals 100% of the time was coded as 0=No.

Missed HIV appointments was measured by asking participants, "In the last six months, did you miss any scheduled regular HIV care appointments? By this, I mean you did not go for a scheduled appointment and did not re-schedule. Participants responding "Yes" were coded as 1=Yes and participants responding "No" were coded as 0=No.

Sub-optimal healthcare utilization was derived by asking participants if they received regular HIV care in the last six months. Responses were coded as 1=Yes and 0=No.

Missed HIV appointments and healthcare utilization measures were collected at visits between October 2013-September 2016. As a result, analyses for missed HIV appointments and sub-optimal healthcare utilization were restricted to study visits occurring between October 2013-September 2016.

Independent Variables

Psychosocial Variables

History of intimate partner abuse was assessed by the responses to two questions asking whether participants ever experienced physical harm by an intimate partner/spouse/boyfriend/girlfriend and whether participants were ever pressured or forced to have sexual contact by an intimate partner/spouse/boyfriend/girlfriend. If participants responded "Yes" to either question, intimate partner abuse was coded as 1=Yes. If participants responded "No" to both questions, intimate partner abuse was coded as 0=No.

History of childhood sexual abuse was derived by a question asking participants whether they have ever been pressured or forced to have sexual contact with anyone before the age of 18 years. Responses indicating "Yes" were coded as 1=Yes and "No" responses were coded as 0=No.

Depressive symptoms was measured using the 20-item Center for Epidemiologic Studies Depression scale (CES-D).[63] The CES-D scale has been used

in previous studies that assess depression among Black women .[64] The standard clinical score ≥ 16 was indicative of depressive symptoms and coded 1=Yes; a CES-D score of < 16 was coded 0=No.

HIV-related discrimination in health care settings was assessed by a single item asking, "'I feel discriminated against in healthcare settings because of my HIV status,'' with responses ranging from "strongly disagree" to "strongly agree." This item was adapted from the Experiences of Discrimination Scale[101] and the HIV Stigma Index.[103] Responses indicating "Strongly Agree" and "Agree" were coded as 1=Yes and responses indicating "Strongly disagree" and "Disagree" were coded as 0=No.

High internalized HIV-related stigma was assessed using the 7-item negative self-image subscale of the HIV Stigma Scale. The responses ranged from "strongly disagree" to "strongly agree" and a scale score ranging from 7-28. A scale score of ≥ 21 was indicative of high internalized HIV-related stigma and coded as 1=Yes; a scale score of < 21 was coded as 0=No.

Heavy alcohol use was assessed by asking WIHS participants about the average number of days per week that a drink of alcohol was consumed. Study participants were also asked about the usual number of drinks consumed per day. The number of drinks per week was calculated by multiplying the reported quantity by the reported frequency per week. In the present study, heavy alcohol use refers to the consumption of 7 or greater drinks per week. This aligns with heavy alcohol consumption limits specified by the National Institute on Alcohol Abuse and Alcoholism.[78] Heavy alcohol use will be dichotomized where participants who

indicated ≥ 7 drinks per week were coded 1=Yes and < 7 drinks per week were coded as 0=No.

Illicit drug use was assessed by asking "Since the last study visit, have you used cocaine, crack, heroin, methamphetamine, hallucinogens, club drugs, or any other illicit or recreational drugs?" Responses were coded as 1=Yes and 0=No.

Participant-level Structural Variables

Lack of health insurance was assessed by asking participants if they had insurance, in which responses were classified into four categories derived from the Kaiser Family Foundation: Medicaid, private or student, Medicare or other public health insurance, and no health insurance. In this study, health insurance categories were collapsed and dichotomized into 1=Yes and 0=No.

Incarceration was assessed by asking participants whether they had been incarcerated in a prison or a jail in the past 6 months. The variable was coded 1=Yes and 0=No.

Annual household income < $24,000 was captured by asking participants about their annual household income. If participants responded with an annual household income of <$24,000 per year, then 1=Yes was coded. If participants responded with an annual household income of ≥ $24,000 per year, then 0=No was coded.

Food insecurity was measured using the 18-item U.S. Household Food Security Survey Module (HFSSM).[79] Previous studies that have used the HFSSM have found that the survey accurately identifies food insecurity in households and has found food insecurity to be associated with multiple health outcomes including

HIV.[13,80-82] The standard HFSSM scoring system was used to identify participants as having high food security (score of 0), marginal food security (score of 1-2), low food security (score of 3-7), and very low food security (score of 8-18).[79] In this study, low and very low food security was indicative of food insecurity and thus was coded as 1=Yes if the HFSSM score was ≥ 3 and 0=No if the HFSSM score was 0-2.

Unstable housing was coded as 1= Yes if the participant reported living in a shelter, jail, residential treatment center, an "other" place, or on the street and coded 0=No if participants reported living in their own house/apartment, parent's house, or someone else's house/apartment.

Neighborhood Structural Variables

Residential addresses were collected starting in 2014 from WIHS study participants who provided informed consent. Addresses were geocoded and assigned a corresponding Federal Information Processing Standard (FIPS) code to be linked to census tract level data from six versions of the ACS 5-year estimates. Residential addresses were collected at even-numbered visits (i.e., one of the two semiannual study visits). Because of this, neighborhood-level structural data from even-numbered study visits were used to impute values for the consecutive odd-numbered study visits (i.e., the study visit for which residential addresses were not collected). ACS 5-year estimates for 2010-2014, 2011-2015, 2012-2016, 2013-2017, 2014-2018, and 2015-2019 were used to derive the neighborhood-level structural variables: concentrated rental cost burdened households, neighborhood unemployment, concentrated poverty, neighborhood low educational attainment, concentrated housing vacancy, neighborhood black racial concentration, concentrated income inequality, and

concentrated uninsurance. In this analysis, each variable was dichotomized to 1=Yes and 0=No.

Concentrated rental cost burdened households were defined as living in a census tract where 50% or more of residents are paying 30% or more of income on rent.

Neighborhood unemployment was defined as living in a census tract where the percent of unemployed civilians, 16 years and older, is greater than 15%.

Concentrated poverty was defined as living in a census tract where 25% or more of residents are living below the federal poverty level.

Neighborhood low educational attainment was defined as living in a census tract where 25% or more of residents had less than a high school diploma.

Concentrated housing vacancy was defined as living in a census tract where 15% or more of vacant residential housing units are present.

Neighborhood black racial concentration was defined as living in a census tract where 50% or more of residents were black/African American. Neighborhood black racial concentration was used a proxy for black racial segregation.[69]

Concentrated income inequality was defined as living in a census tract with a Gini coefficient of 0.44. Gini coefficients range from 0 to 1, with 0 indicating complete equality and 1 indicating complete inequality. High income inequality has been identified as 0.44.[69]

Neighborhood uninsurance was defined as living in a census tract where 15% or more of the residents are uninsured.

Syndemic Parameterizations

Three syndemic parameterizations were applied in this analysis. First, a cumulative syndemic index, ranging from 0-20, was created by summing all psychosocial and structural variables for which all variables had a binary coding structure of 1= Yes and 0 = No. This binary coding structure made it so that no one factor was worth more than the others. Second, the psychosocial and structural syndemic factors were categorized into three syndemic group indices reflecting the level of influence: the psychosocial syndemic group included history of intimate partner abuse, history of childhood sexual abuse, depressive symptoms, HIV-related discrimination in health care settings, high internalized HIV-related stigma, illicit drug use, and heavy alcohol use; the participant-level structural syndemic group included incarceration, annual household income less than $24,000, lack of health insurance, unstable housing, and food insecurity; and the neighborhood-level structural syndemic group included concentrated rental-burdened households, neighborhood unemployment, neighborhood low educational attainment, concentrated housing vacancy, neighborhood black racial concentration, concentrated poverty, concentrated income inequality, and concentrated uninsurance. Lastly, exposure to none, one, two, or three syndemic groups was examined.

Statistical Analysis

Baseline characteristics were summarized with frequencies and percentages for all variables except for cumulative syndemic score, psychosocial syndemic group score, participant-level structural syndemic group score, and neighborhood-level syndemic group score. Due to being continuous variables these variables were summarized using means and standard deviations. Unadjusted generalized estimating equations (GEE) models with the logit link function were conducted to test the associations between each psychosocial and structural factor. A series of generalized linear mixed models with the logit link and random effect for slope and intercept were conducted using interaction terms (e.g., cumulative syndemic count*time) in order to test the longitudinal effects of syndemic parameterizations on HIV care outcome.

Unadjusted and adjusted generalized linear mixed models were run to estimate odds ratios measuring the longitudinal relationships for each syndemic parameterization on each HIV care outcome. Covariates including study participant's age, education level, and employment status served as potential confounders and therefore was controlled for in adjusted models. Covariates were chosen based on previous WIHS studies that adjusted for these variables in study analyses. Outliers were assessed by measuring Cook's distance, leverages, and studentized residuals; there was no evidence of overly influential observations. Variance inflation and multicollinearity were assessed by measuring the variance inflation factor (VIF) values; results indicated that there was no evidence of variance inflation (VIF > 5). Additionally, all models utilized complete case analysis.

For all models, maximum likelihood of model parameters was based on the Laplace approximation. Odds ratios (OR) and 95% confidence intervals were

reported. All analyses were performed using SAS Studio (SAS Institute, Inc., Cary, NC).

RESULTS

Baseline Characteristics (Tables 1 and 2)

For the sub-optimal HIV medication adherence outcome, data was analyzed from a total of 969 Black women enrolled in WIHS over 12 study visits. At baseline, 16.8% of Black women reported taking her HIV antiretrovirals as prescribed less than 95% of the time. Because data ascertained for the missed HIV appointment and sub-optimal healthcare utilization outcomes were restricted to study visits occurring between October 2013-September 2016, data from a total of 806 women were analyzed. At baseline, 12.1% of Black women reported missing their HIV appointments in the last six month and 9.8% of Black women reported not receiving regular HIV care in the past six months (Table 1).

In all, over one-third of Black women in the study experienced intimate partner abuse (36.2%), depressive symptoms (31.8%), and living in census tracts with concentrated housing vacancy (33.9%). A large proportion (74.8%) of Black women had annual household incomes less than $24,000, 63.7% reported living in census tracts with concentrated rental burdened households, 58% reported living in census tracts with neighborhood black racial concentration, 59.7% reported living in census tracts with concentrated income inequality, and 56.6% reported living in census tracts with concentrated uninsurance. In this analytic sample, the mean cumulative syndemic score was 6.3 (SD=2.8); the psychosocial syndemic group mean score was

1.3 (SD=1.2); the participant-level syndemic group mean score was 1.1 (SD=0.8); and the neighborhood-level syndemic group mean score was 3.9 (SD=2.1). When examining the number of syndemic groups, 43.5% of Black women reported experiencing factors from at least 2 syndemic groups (Table 1).

At baseline, there were several associations observed between psychosocial and structural factors. Black women who lived in census tracts with neighborhood black racial concentration had lower odds of reporting HIV-related discrimination in health care settings (OR=0.71, 95% CI: 0.52-0.97), history of childhood sexual abuse (OR=0.70, 95% CI: 0.51-0.95), and living in census tracts with neighborhood low educational attainment (OR=0.74, 95% CI: 0.61-0.90). Black women who reported being incarcerated in the last 6 months had more than a five-fold odds of reporting illicit drug use compared to Black women who did not report incarceration (OR=5.81, 95% CI = 3.86-8.75). Similarly, Black women who reported an annual household income of less than $24,000 had 5 times the odds of reporting unstable housing (OR=5.91, 95% CI: 1.44-24.23; Table 2).

Longitudinal Analyses of HIV Care Outcomes and Syndemic Parameterizations (Table 3)

Trajectory effects for cumulative syndemic score and neighborhood-level structural syndemic group score was significantly associated with sub-optimal HIV medication adherence. When adjusted for participant's age, employment status, and education level, a higher cumulative syndemic score was associated with increased odds of reporting sub-optimal HIV medication adherence (OR=1.04, 95% CI: 1.01-

1.06). Similarly, a higher neighborhood-level structural syndemic group score was associated with increased odds of reporting sub-optimal HIV medication adherence (OR=1.04, 95% CI: 1.01-1.08). Black women in two syndemic groups had increased odds of reporting sub-optimal HIV medication adherence (OR=2.16, 95% CI: 1.10-4.23). Odds of reporting sub-optimal HIV medication adherence were significantly associated with being in all three syndemic groups (OR=2.88, 95% CI: 1.32-6.29). In the adjusted analysis, Black women in all three syndemic groups had higher odds of reporting missed HIV appointments (OR=3.39, 95% CI: 1.06-10.92). There were no associations observed between syndemic parameterizations and sub-optimal healthcare utilization.

DISCUSSION

Our study provides robust evidence of longitudinal syndemic effects on increased sub-optimal HIV medication adherence and missed HIV appointments among a cohort of Black women living with HIV. These findings indicate that the cumulative effect of psychosocial and structural factors such as depressive symptoms, unstable housing, HIV stigma, and concentrated poverty operate as barriers to successfully navigating HIV care.

For sub-optimal HIV medication adherence, Black women with higher cumulative syndemic scores had higher odds of reporting sub-optimal HIV medication adherence over time. This positive association is consistent with previous literature among those living with HIV.[58,61] Our study also provides evidence of the relationship between neighborhood syndemic effects and sub-optimal HIV

medication adherence with the finding that Black women reporting higher neighborhood-level structural syndemic scores had increased odds of reporting sub-optimal HIV medication adherence over time. These results add to the evidence from cross-sectional analyses which have found positive associations between structural syndemic count and HIV medication nonadherence.[61] Furthermore, this study builds on literature that has examined neighborhood-level structural factors individually to better understand the lived conditions and their pathways to HIV care vulnerability.

Results from our study highlight the clustering effects of psychosocial and structural factors that influence sub-optimal HIV medication adherence and HIV missed appointments. Black women in all three syndemic groups had increased odds of reporting sub-optimal HIV medication adherence and missed HIV appointments. These findings suggest that psychosocial, participant-level structural, and neighborhood-level structural syndemic factors do not act alone in influencing HIV care outcomes; but rather, co-exist and converge with each other to exacerbate negative HIV care outcomes. There were no statistically significant associations observed between syndemic parameterizations and sub-optimal healthcare utilization. This finding was not expected but may be indicative that Black women who report sub-optimal healthcare utilization may experience a different combination of psychosocial and structural syndemic factors that were not included in this analysis.

The study results also support the use of the syndemics theory when assessing the relationship between psychosocial and structural factors on HIV care outcomes among Black women living with HIV. Previous studies using the syndemics theory center on the SAVA syndemic, in which substance use, violence, and HIV/AIDS

mutually enhance each other and worsens health outcomes.[44-47] The SAVA syndemic framework has been applied to a plethora of studies when exploring HIV outcomes among women living with HIV; through this study, we now have evidence that multiple and multilevel factors that extend beyond the SAVA syndemic negatively impacts HIV treatment and care.

Our study findings are not without limitations. Although the use of neighborhood measures provided greater context into the relationship between syndemic effects and HIV care outcomes, the neighborhood-level structural factors were created by using the participant's address information and linked to the 5-year ACS corresponding to the current year of the study visit. By doing so, the year linked to the study visit may not accurately reflect the characteristics of the census tract at time of study visit thereby possibly resulting in misclassification of the neighborhood measures. The researchers chose to link ACS estimates to the current year of the study visit because the analysis included study visits for which relevant 5-year ACS estimates did not yet exist. Second, the study variables included in this study may not represent the extent of psychosocial, participant-level structural, and neighborhood structural characteristics that may influence HIV care outcomes among Black women . This limitation also could explain why there were not statistically significant observations observed with sub-optimal healthcare utilization. It is possible that Black women who do not receive regular HIV care may have a different syndemic profile and experience a different set of psychosocial and syndemic factors that were not units of analysis in this study. Third, the study measures the association between the number of syndemic groups and HIV care outcomes; however, due to the nature

of this study, we were not able to look further into this association and determine the specific combinations of syndemic groups that resulted in the greatest associations with HIV care outcomes. Therefore, further analyses using latent class analyses are needed to identify patterns and risk profiles of psychosocial and structural syndemic factors on HIV care outcomes. Finally, self-reported measures were used to collect information on outcome and exposure variables thereby influencing the possibility of bias and misclassification.

CONCLUSION

Study findings demonstrate the cumulative effect of psychosocial and structural forces acting on HIV care outcomes among HIV-positive Black women in WIHS. This research supports the need for comprehensive HIV care and treatment interventions that effectively address multiple psychosocial and structural issues that intersect with each other and negatively impacts HIV care and treatment outcomes. This approach involves profound understanding and work done on the systemic level to address existing structures driving health inequities among Black women .

Table 1: Syndemic and HIV care outcomes reported at baseline among Black women in the Women's Interagency HIV Study

	HIV-Positive Black women
Variables Reported since Last Study Visit	**N (%)**
Psychosocial Characteristics (N=969)	
History of Intimate Partner Abuse	
Yes	351 (36.2)
No	568 (58.6)
Missing	50 (5.2)
History of Childhood Sexual Abuse	
Yes	136 (14.0)
No	753 (77.7)
Missing	80 (8.3)
Depressive Symptoms	
Yes	308 (31.8)
No	635 (65.5)
Missing	26 (2.7)
Perceived HIV-related discrimination in health care settings	
Yes	133 (13.7)
No	813 (83.9)

Missing	23 (2.4)
High Internalized HIV-Related Stigma	
Yes	60 (6.2)
No	890 (91.9)
Missing	19 (2.0)
Illicit Drug Use	
Yes	100 (10.3)
No	855 (88.2)
Missing	14 (1.4)
Heavy Alcohol Use	
Yes	129 (13.3)
No	826 (85.2)
Missing	14 (1.4)
Structural Factors	
Participant-level Characteristics **(N=969)**	
Incarceration	
Yes	26 (2.7)
No	932 (96.2)
Missing	11 (1.1)
Food Insecurity	

Yes	241 (24.9)
No	725 (74.8)
Missing	3 (0.3)
Unstable Housing	
Yes	44 (4.5)
No	913 (94.2)
Missing	12 (1.2)
Health Insurance Status	
Has Health Insurance	69 (7.1)
Does Not Have Health Insurance	884 (91.2)
Missing	16 (1.7)
Annual Household Income <$24,000	
Yes	725 (74.8)
No	209 (21.6)
Missing	35 (3.6)
Neighborhood-level Characteristics **(N=969)**	
Concentrated rental burdened households *(living in a census tract where 50% or more of residents are paying 30% or more of income on rent)*	
Yes	617 (63.7)
No	352 (36.3)

Neighborhood low educational attainment *(living in a census tract where 25% or more of residents had less than a high school diploma)*	
Yes	286 (29.5)
No	683 (70.5)
Neighborhood unemployment *(living in a census tract where the percent of unemployed civilians, 16 years and older, is greater than 15%)*	
Yes	399 (41.2)
No	570 (58.8)
Concentrated housing vacancy *(living in a census tract where 15% or more of vacant residential housing units are present)*	
Yes	328 (33.9)
No	641 (66.2)
Neighborhood black racial concentration *(living in a census tract where 50% or more of residents were black/African American)*	
Yes	562 (58.0)
No	407 (42.0)
Concentrated poverty *(living in a census tract where 25% or more of residents are living below the federal poverty level)*	
Yes	432 (44.6)
No	537 (55.4)
Concentrated income inequality *(living in a census tract with a Gini coefficient of 0.44)*	

Yes	578 (59.7)
No	391 (40.4)
Concentrated uninsurance *(living in a census tract where 15% or more of the residents are uninsured)*	
Yes	548 (56.6)
No	421 (43.5)
Syndemic Parameterizations	
Cumulative Syndemic Score, M (SD)	6.3 (2.8)
Psychosocial Syndemic Group Score, M (SD)	1.3 (1.2)
Participant level Syndemic Group Score, M (SD)	1.1 (0.8)
Neighborhood-level Syndemic Group Score, M (SD)	3.9 (2.1)
Number of Syndemic Groups	
0	93 (9.6)
1	454 (46.9)
2	295 (30.4)
3	127 (13.1)
HIV Care Outcomes	
Sub-optimal HIV Medication Adherence (N=969)	
Yes	163 (16.8)
No	681 (70.3)
Missing	125 (12.9)

Missed HIV appointments (N= 803)	
Yes	97 (12.1)
No	693 (86.3)
Missing	13 (1.6)
Sub-optimal Healthcare Utilization (N= 803)	
Yes	79 (9.8)
No	711 (88.5)
Missing	13 (1.6)

Table 2: Bivariate odds ratios between each psychosocial and structural syndemic factor at baseline

	Intimate Partner Violene	History of Sexual Childhood Abuse	Depressive Symptoms	HIV-related discrimination in health care settings	High Internalized HIV-Related Stigma	Illicit Drug Use	Heavy Alcohol Use	Incarceration	Food Insecurity	Unstable Housing	Annual household income <$24,000	Lack of Health Insurance	Concentrated Rental Cost Burdened	Neighborhood low educational attainment	Neighborhood Unemployment	Concentrated Poverty	Concentrated Housing Vacancy	Neighborhood Black Racial Concentration	Concentrated Income Inequality
Syndemic Variables	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI
History of Childhood Sexual Abuse	**1.93 (1.64-2.27)**	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Depressive Symptoms	1.08 (0.90-1.28)	1.06 (0.76-1.48)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Perceived HIV-related discrimination in health care settings	1.08 (0.86-1.36)	1.16 (0.77-1.76)	**1.86 (1.53-2.26)**	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
High Internalized HIV-Related Stigma	1.22 (0.91-1.63)	1.23 (0.68-2.20)	**2.76 (2.38-3.24)**	**2.98 (2.68-4.33)**	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Illicit Drug Use	1.20 (0.94-1.53)	0.89 (0.51-1.54)	**1.83 (1.49-2.26)**	1.00 (0.60-1.67)	**1.90 (1.02-3.63)**	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Heavy Alcohol Use	1.14 (0.91-1.43)	0.76 (0.45-1.27)	**1.41 (1.13-1.77)**	0.89 (0.55-1.45)	1.61 (0.88-2.94)	**4.64 (3.26-6.59)**	—	—	—	—	—	—	—	—	—	—	—	—	—
Incarceration	1.16 0.74-1.82)	1.39 (0.63-3.08)	**1.93 (1.40-2.65)**	1.13 (0.45-2.81)	0.62 (0.09-4.30)	**5.81 (3.86-8.75)**	**2.26 (1.30-4.30)**	—	—	—	—		—	—	—	—	—	—	—
Food Insecurity	**1.27 (1.07-1.51)**	1.28 (0.91-1.79)	**2.22 (1.87-2.64)**	**1.81 (1.32-2.49)**	**3.65 (2.24-5.94)**	**2.26 (1.57-3.27)**	1.22 (0.86-1.74)	**3.00 (1.36-6.58)**	—	—	—	—	—	—	—	—	—	—	—
Unstable Housing	0.92 (0.60-1.39)	1.58 (0.90-2.78)	**1.76 (1.33-2.34)**	1.50 (0.82-2.75)	**2.75 (1.33-5.69)**	**3.09 (1.88-5.08)**	1.19 (0.59-2.38)	**3.77 (1.36-10.48)**	**1.89 (1.34-2.66)**	—	—	—	—	—	—	—	—	—	—
Annual household income <$24,000	1.17 (0.94-1.45)	1.14 (0.77-1.69)	**2.06 (1.61-2.80)**	0.89 (0.62-1.28)	2.09 (0.96-4.53)	**3.22 (1.89-6.54)**	**1.84 (1.13-3.00)**	2.02 (0.61-6.70)	**2.03 (1.42-2.90)**	**5.91 (1.44-24.23)**	—	—	—	—	—	—	—	—	—
Lack of Heath Insurance	0.86 (0.60-1.23)	0.99 (0.53-1.85)	1.12 (0.80-1.55)	1.15 (0.65-2.03)	1.39 (0.62-3.13)	**1.75 (1.01-3.03)**	1.31 (0.76-2.26)	1.67 (0.51-5.42)	**1.17 (0.80-1.72)**	2.42 (1.12-5.22)	0.87 (0.74-1.04)	—	—	—	—	—	—	—	—
Concentrated Rental cost burdened	0.95 (0.80-1.12)	1.01 (0.73-1.39)	1.18 (0.97-1.44)	1.01 (0.73-1.41)	1.11 (0.66-1.87)	1.05 (0.71-1.54)	1.13 (0.80-1.58)	1.53 (0.65-3.61)	1.27 (1.00-1.61)	0.99 (0.54-1.81)	1.03 (0.96-1.11)	1.21 (0.74-1.97)	—	—	—	—	—	—	—
Neighborhood low educational attainment	1.12 (0.94-1.33)	0.72 (0.50-1.05)	0.93 (0.76-1.14)	0.87 (0.61-1.24)	0.59 (0.32-1.09)	0.84 (0.55-1.29)	1.00 (0.70-1.42)	1.26 (0.57-2.80)	0.95 (0.75-1.22)	**0.31 (0.12-0.77)**	**1.21 (1.14-1.29)**	0.66 (0.38-1.16)	**1.26 (1.15-1.38)**	—	—	—	—	—	—
Neighborhood Unemployment	1.09 (0.92-1.28)	0.85 (0.61-1.17)	1.20 (1.00-1.44)	0.76 (0.54-1.05)	0.87 (0.52-1.43)	1.03 (0.71-1.49)	1.12 (0.81-1.55)	1.43 (0.67-3.04)	1.32 (1.06-1.64)	0.74 (0.40-1.35)	**1.18 (1.10-1.26)**	0.97 (0.61-1.55)	**1.34 (1.22-1.47)**	**2.29 (1.90-2.79)**	—	—	—	—	—
Concentrated Poverty	1.04 (0.88-1.22)	0.78 (0.57-1.07)	1.08 (0.90-1.30)	1.03 (0.75-1.41)	0.81 (0.49-1.34)	1.10 (0.76-1.59)	1.18 (0.86-1.63)	1.46 (0.68-3.12)	1.10 (0.88-1.37)	1.04 (0.58-1.85)	**1.26 (1.18-1.35)**	1.13 (0.72-1.79)	**1.44 (1.31-1.58)**	**4.59 (3.56-5.90)**	**3.44 (2.86-4.12)**	—	—	—	—
Concentrated Housing Vacancy	0.98 (0.82-1.17)	0.85 (0.61-1.20)	**1.39 (1.16-1.67)**	**1.52 (1.11-2.09)**	1.48 (0.90-2.42)	**2.01 (1.39-2.90)**	**1.43 (1.04-1.98)**	**3.10 (1.42-6.77)**	**1.64 (1.32-2.04)**	**3.07 (1.70-5.56)**	**1.21 (1.13-1.28)**	**2.23 (1.42-3.52)**	**1.24 (1.13-1.36)**	0.99 (0.80-1.21)	**2.24 (1.94-2.59**	**1.90 (1.66-2.17)**	—	—	—
Neighborhood Black Racial concentration	0.85 (0.72-1.00)	**0.70 (0.51-0.95)**	1.01 (0.84-1.22)	**0.71 (0.52-0.97)**	0.71 (0.43-1.15)	1.27 (0.86-1.87)	0.99 (0.72-1.37)	1.63 (0.71-3.70)	0.98 (0.79-1.23)	1.26 (0.69-2.30)	0.98 (0.91-1.05)	1.34 (0.83-2.17)	**1.33 (1.19-1.47)**	**0.74 (0.61-0.90)**	**2.48 (2.01-2.93)**	**1.42 (1.22-1.65)**	**3.17 (2.48-4.06)**	—	—
Concentrated Income Inequality	**1.28 (1.07-1.53)**	0.94 (0.69-1.28)	1.06 (0.88-1.28)	1.04 (0.75-1.43)	0.81 (0.50-1.33)	1.21 (0.82-1.78)	1.36 (0.96-1.91)	1.29 (0.58-2.85)	0.98 (0.78-1.22)	1.08 (0.60-1.95)	**1.19 (1.10-1.28)**	0.78 (0.50-1.23)	**1.11 (1.00-1.22)**	**1.50 (1.21-1.86)**	**1.59 (1.34-1.89)**	**2.76 (2.26-3.37)**	**1.59 (1.30-1.94)**	**1.08 (0.97-1.21)**	—
Concentrated Uninsurance	**0.84 (0.72-1.00)**	0.74 (0.54-1.01)	**1.47 (1.21-1.79)**	1.00 (0.73-1.38)	1.39 (0.83-2.33)	**1.94 (1.28-2.96)**	1.27 (0.91-1.78)	**4.19 (1.48-12.05)**	**1.52 (1.20-1.92)**	1.21 (0.67-2.18)	**1.14 (1.06-1.23)**	**2.49 (1.48-4.29)**	**1.53 (1.37-1.71)**	**1.82 (1.46-2.26)**	**1.66 (1.41-1.97)**	**1.64 (1.40-1.92)**	**2.30 (1.86-2.86)**	**1.31 (1.17-1.47)**	0.99 (0.89-1.10)

*Estimates where p<0.05 are bolded to facilitate interpretation

Table 3: Longitudinal analyses of the associations between syndemic factors and HIV care outcomes among Black women

	Sub-optimal HIV Medication Adherence (N= 969)		Missed HIV Appointments (N=806)		Sub-optimal Healthcare Utilization (N=806)	
Syndemic Variables	OR (95% CI)	aOR (95% CI)	OR (95% CI)	aOR (95% CI)	OR (95% CI)	aOR (95% CI)
Cumulative Syndemic Score	**1.04 (1.01-1.06)**	**1.04 (1.01-1.06)**	1.01 (0.93-1.10)	1.01 (0.93-1.11)	1.03 (0.95-1.12)	1.05 (0.96-1.15)
Psychosocial Syndemic Group Score	1.03 (0.97-1.09)	1.03 (0.97-1.09)	1.02 (0.85-1.22)	1.03 (0.85-1.24)	1.06 (0.88-1.28)	1.09 (0.89-1.32)
Participant-level Structural Syndemic Group Score	1.06 (0.97-1.16)	1.06 (0.97-1.16)	0.86 (0.66-1.14)	0.88 (0.65-1.19)	1.11 (0.83-1.49)	1.19 (0.88-1.63)
Neighborhood-level Structural Syndemic Group Score	**1.04 (1.01-1.07)**	**1.04 (1.01-1.08)**	1.03 (0.93-1.15)	1.02 (0.91-1.15)	1.03 (0.92-1.15)	1.03 (0.92-1.16)
Number of Syndemic Groups						
0	REF	REF	REF	REF	REF	REF
1	0.98 (0.52-1.84)	1.02 (0.54-1.94)	1.83 (0.64-5.19)	1.61 (0.54-4.83)	0.66 (0.27-1.58)	0.64 (0.26-1.56)
2	**2.08 (1.07-4.03)**	**2.16 (1.10-4.23)**	2.53 (0.87-7.32)	2.11 (0.69-6.42)	0.93 (0.38-2.29)	0.84 (0.33-2.10)
3	**2.73 (1.27-5.87)**	**2.88 (1.32-6.29)**	**4.20 (1.37-12.88)**	**3.39 (1.06-10.92)**	0.96 (0.35-2.65)	0.84 (0.30-2.36)

*Estimates where p<.05 are bolded to facilitate interpretation.
*Adjusted models are controlled for study participant's age, education level, employment status, and HIV status
*Five models were fit for each outcome: one with cumulative syndemic score, one with psychosocial syndemic group score, one with participant-level structural syndemic group score, one with neighborhood-level syndemic group score, and one with syndemic group number

Chapter 6 – Conclusions & Public Health Significance

The study analyses illustrate the way in which structural and psychosocial factors accumulate and converge to form a syndemic and the influence of that syndemic on HIV-related outcomes. The development of HIV prevention and intervention programs often focused on changing the behavior of the targeted population; however, such strategies may be obsolete when it comes to HIV prevention among Black women . HIV prevention models and strategies should be developed with the intersectionality framework in mind; thereby considering the social contexts that intersect with the lived experiences of Black women.

The core tenets of intersectionality are that social identities are intersecting, rather than unidimensional and independent of each other, social identities are placed at the starting point or focal point of an analyses, and social identities not only intersect with each other but also intersect with structural forces, thereby representing a multilevel intersection.[48] This analysis is rooted in intersectionality—that is, the examination of psychosocial and structural syndemic effects on a multitude of HIV-related outcomes is explored through the vantage point of Black women. This study highlights the need for applying the intersectionality framework in epidemiological studies.

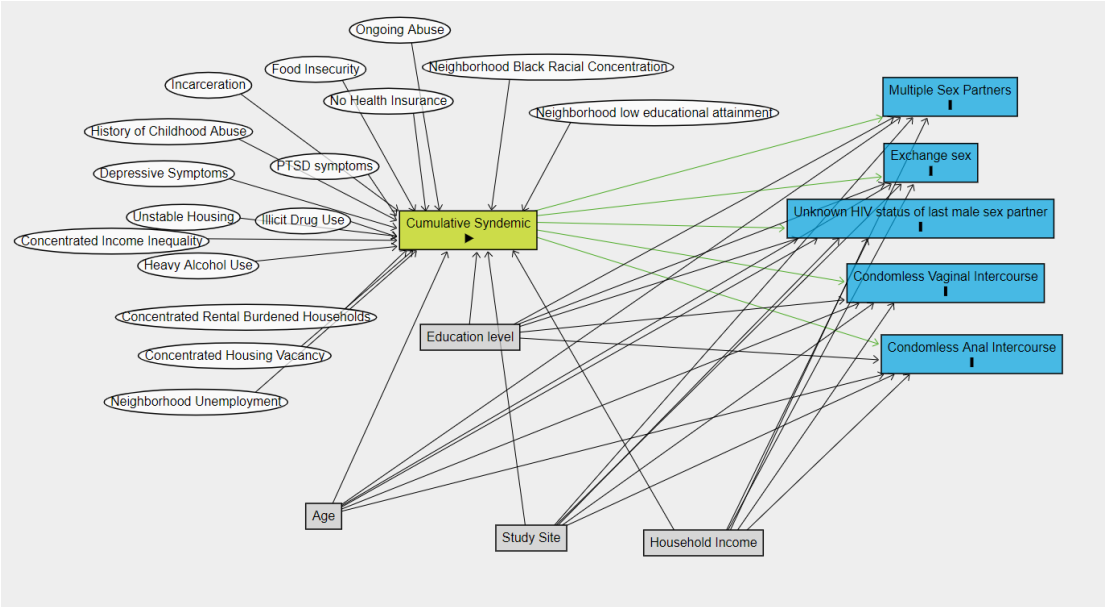
This study highlights the role of structural factors in increasing Black women's vulnerability to HIV. These structural factors extend beyond the factors used in this study and include institutional and policy-related structural factors that would need to be reformed if we are to effectively address the socio-structural issues

that drive HIV disparities for Black women . Findings from this study will emphasize the dire need for macro-level policy initiatives such as workforce development programs to reduce poverty and increase incomes and mandated policies aimed at reducing discrimination when hiring individuals who have been previously incarcerated--that is, policy initiatives specifically targeting structural systems that negatively influence HIV risk and care outcomes of Black women .

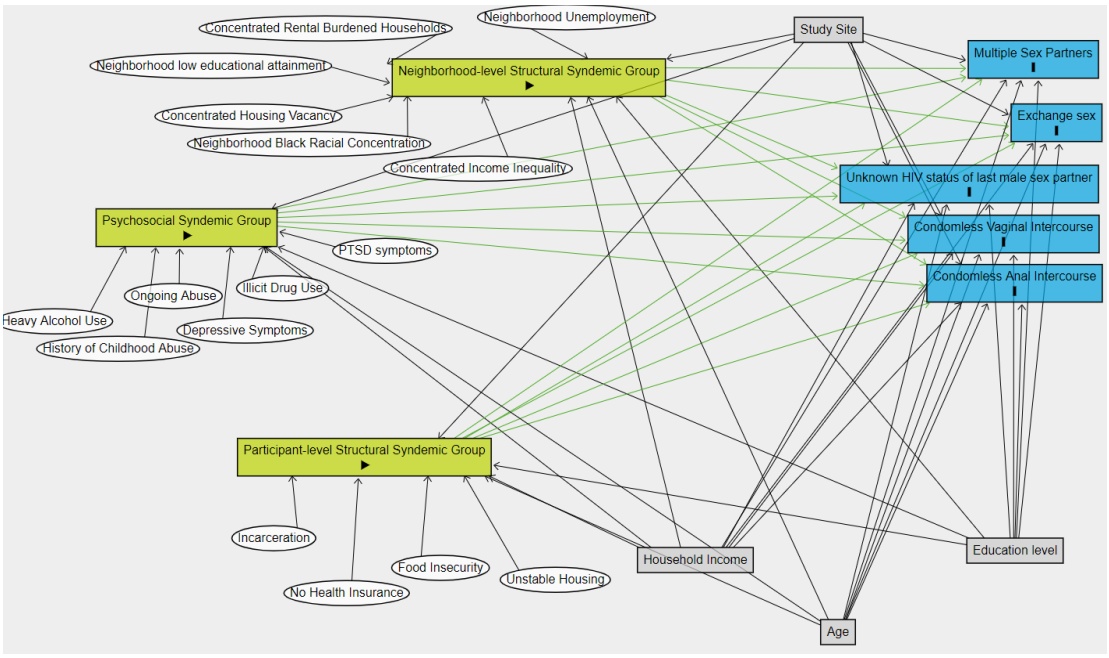
The use of the syndemic theory highlights the complex intertwining effects of psychosocial and structural factors on HIV-related outcomes for Black women . These syndemic effects greatly impact women's lives and behaviors in a complex and continuous way, and therefore have significant public health implications in how we comprehensively address the compound burden of psychosocial and structural syndemic effects on HIV in prevention and intervention programs, policies, and economic institutions moving forward.

Appendices

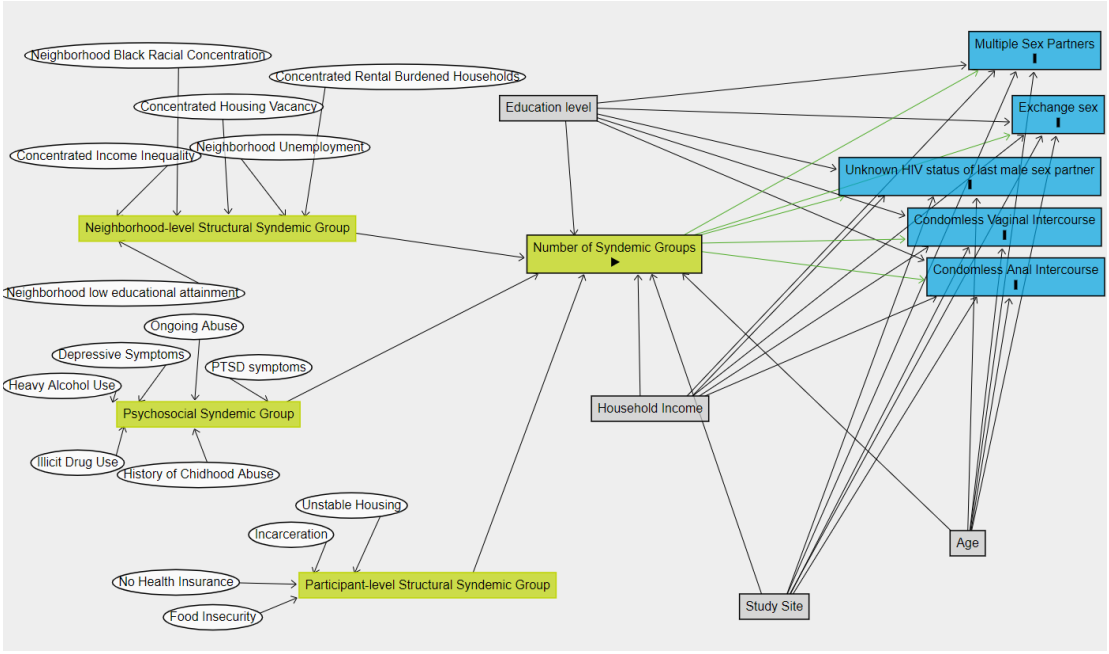
Appendix A.1: Directed Acyclic Graph for Manuscript 1, Syndemic Parameterization 1



Appendix A.2: Directed Acyclic Graph for Manuscript 1, Syndemic Parameterization 2

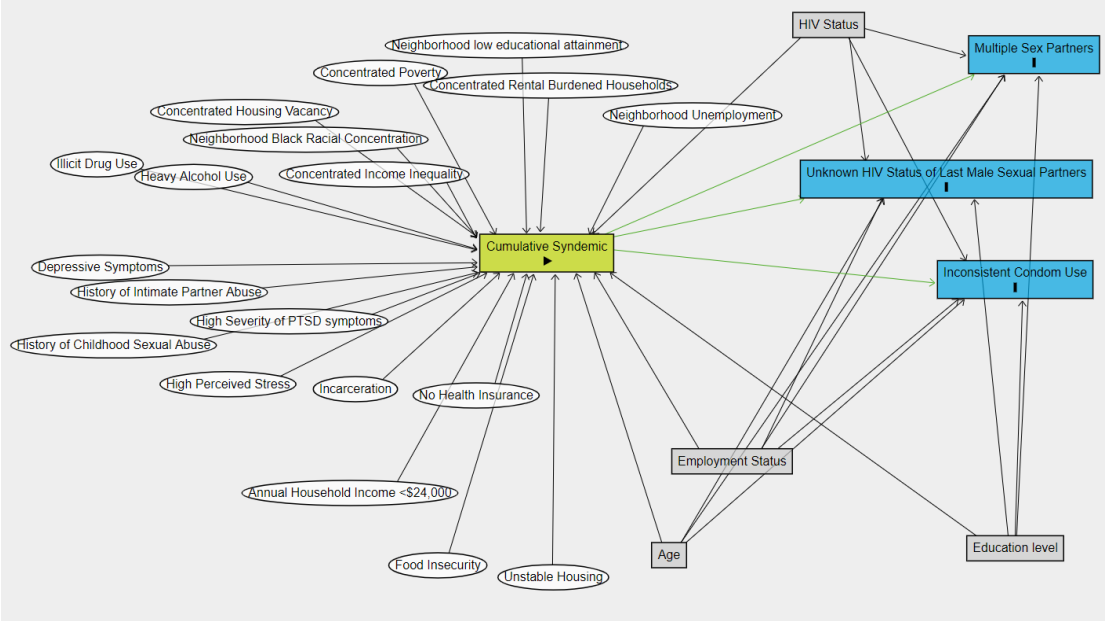


Appendix A.3: Directed Acyclic Graph for Manuscript 1, Syndemic Parameterization 3

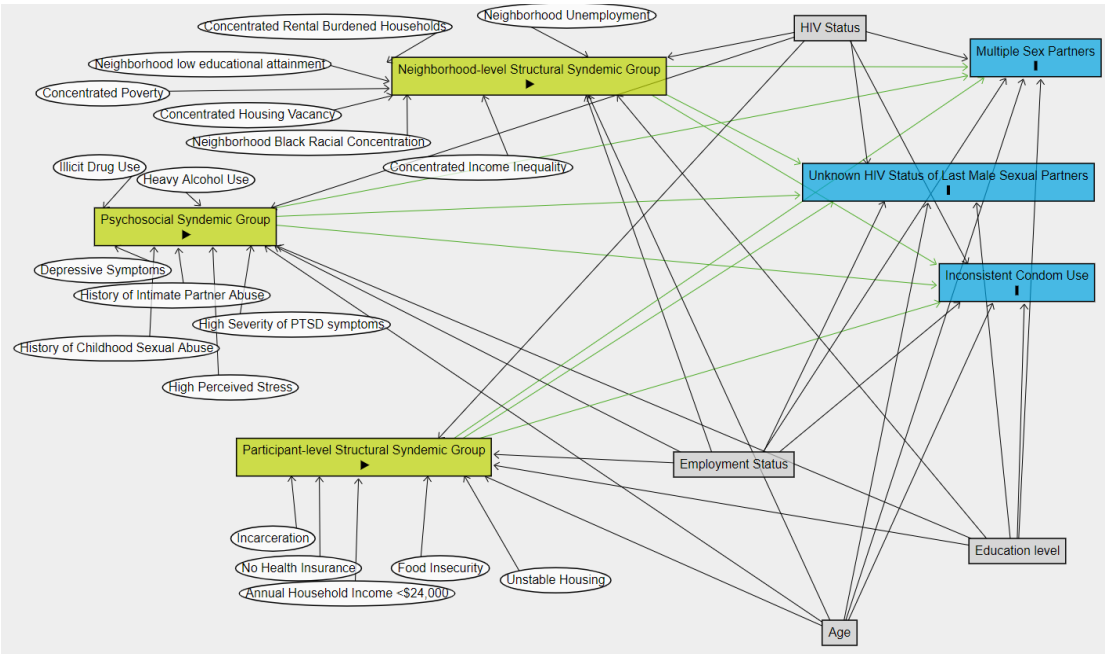


Appendix B.1: Directed Acyclic Graph for Manuscript 2, Syndemic Parameterization

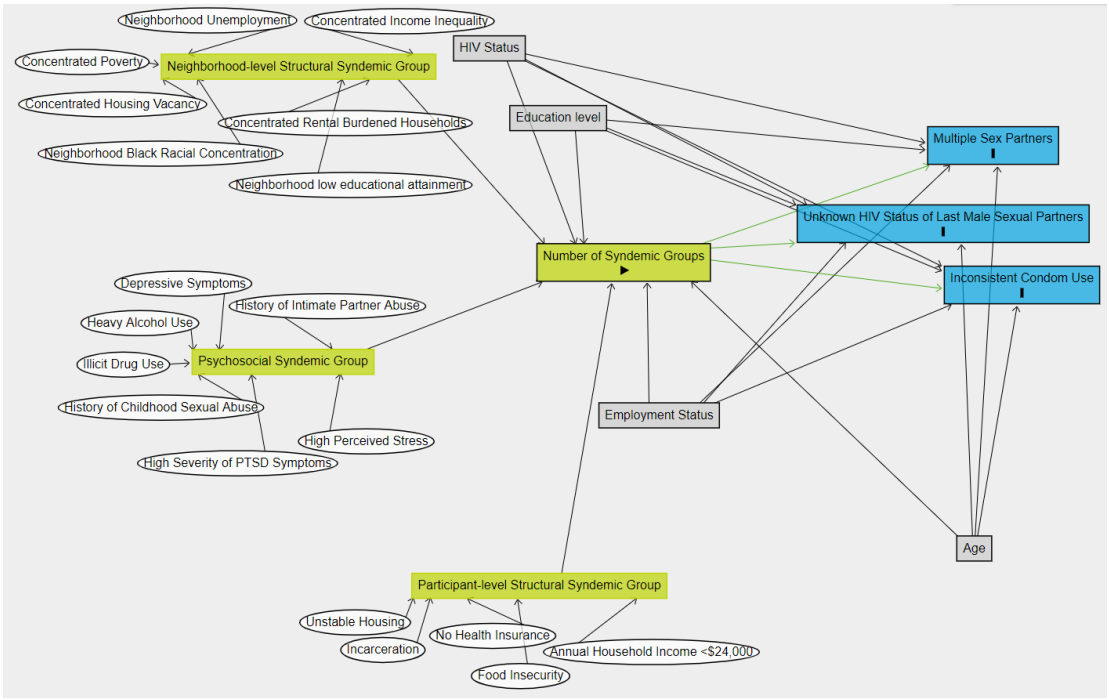
1



Appendix B.2: Directed Acyclic Graph for Manuscript 2, Syndemic Parameterization 2

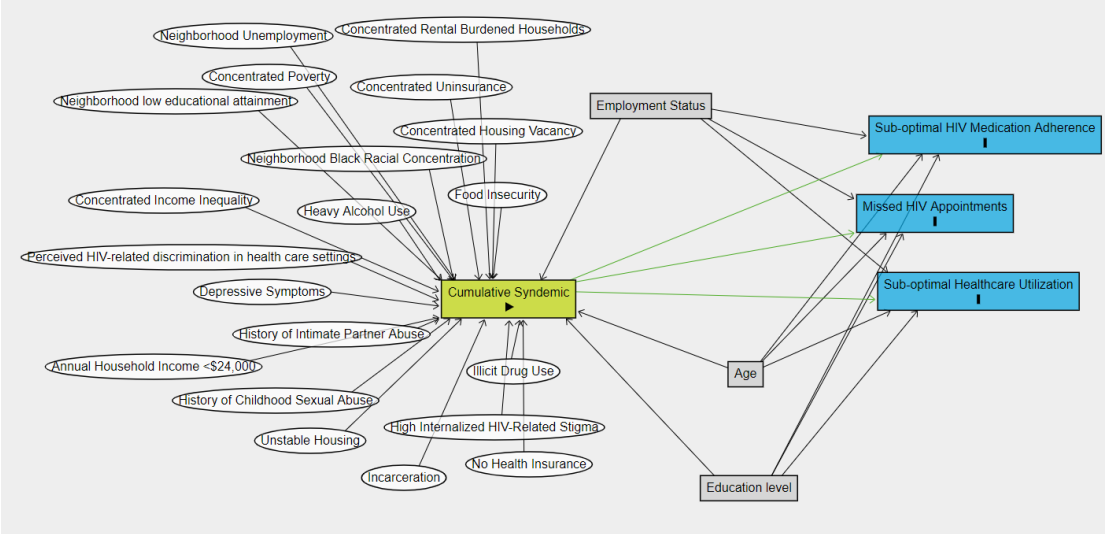


Appendix B.3: Directed Acyclic Graph for Manuscript 2, Syndemic Parameterization 3

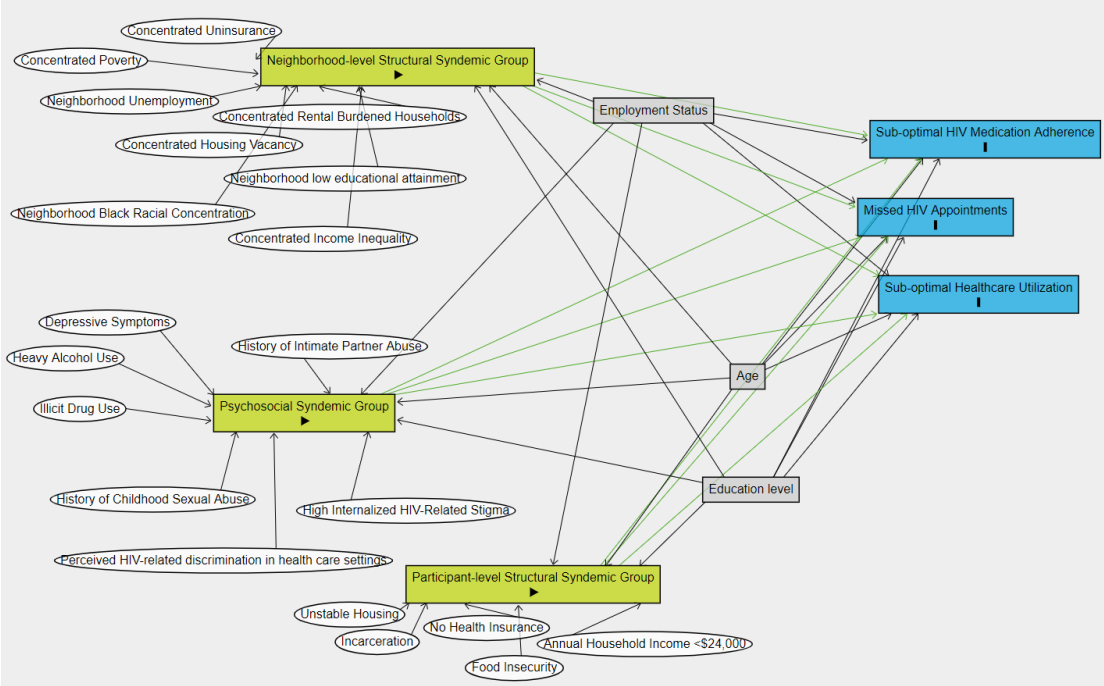


Appendix C.1: Directed Acyclic Graph for Manuscript 3, Syndemic Parameterization

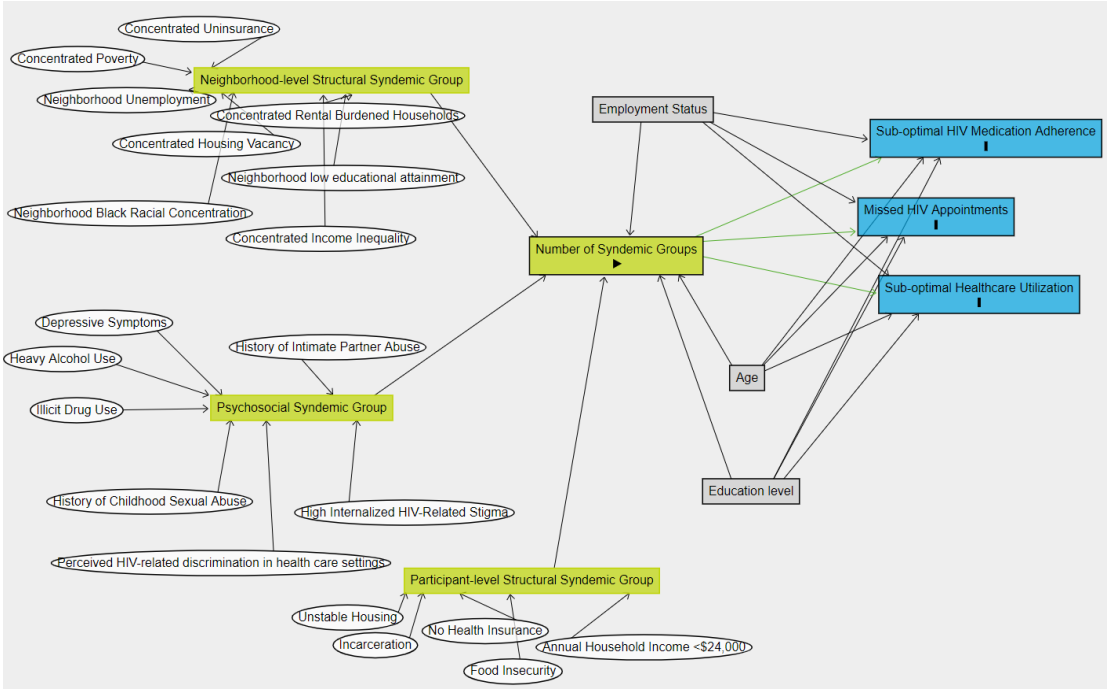
1



Appendix C.2: Directed Acyclic Graph for Manuscript 3, Syndemic Parameterization 2



Appendix C.3: Directed Acyclic Graph for Manuscript 3, Syndemic Parameterization 3



Appendix D: IRB Exemption Letter

UNIVERSITY OF MARYLAND
INSTITUTIONAL REVIEW BOARD

1204 Marie Mount Hall
College Park, MD 20742-5125
TEL 301.405.4212
FAX 301.314.1475
irb@umd.edu
www.umresearch.umd.edu/IRB

DATE:	August 9, 2021
TO:	Lakeshia Watson, MPH
FROM:	University of Maryland College Park (UMCP) IRB
PROJECT TITLE:	[1759046-1] Exploring Psychosocial and Structural Syndemic Effects as Predictors for HIV-Related Outcomes among Black Women
REFERENCE #:	
SUBMISSION TYPE:	New Project
ACTION:	DETERMINATION OF EXEMPT STATUS
DECISION DATE:	August 9, 2021
REVIEW CATEGORY:	Exemption category # *4*

Thank you for your submission of New Project materials for this project. The University of Maryland College Park (UMCP) IRB has determined this project is EXEMPT FROM IRB REVIEW according to federal regulations.

We will retain a copy of this correspondence within our records.

If you have any questions, please contact the IRB Office at 301-405-4212 or irb@umd.edu. Please include your project title and reference number in all correspondence with this committee.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within University of Maryland College Park (UMCP) IRB's records.

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