Modeling Mechanisms of Human Immunodeficiency Virus and Sexually Transmitted Infections Contraction Among Serodiscordant Couples

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Abstract

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This dissertation seeks to incrementally explain the impact of individual, interpersonal, and environmental levels of risk upon HIV/STI incidents among heterosexual African American serodiscordant couples residing in four metropolitan cities. Using archival data from a cluster-RCT (Project EBAN) and governmental surveillance reports, analytic methods that can model heterogeneous pathways within and across each level of risk were used. Findings from this dissertation revealed unique patterns and pathways via which African American females in serodiscordant relationships contracted HIV/STI.

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Dedication

To Dadaji…

Chapter 1: Literature Review

While the overall rate of new Human Immunodeficiency Virus (HIV) infections has been declining over the past two decades in the United States (U.S.), this has not been the case among African Americans. On the contrary, HIV infection rates have been on the rise in this group, particularly among African American women, and African American men who have sex with men (MSM). Between 2010 and 2018, on average 4000 African American women became infected with HIV each year as a result of heterosexual contact. African Americans accounted for nearly 40% of the 39,700 new cases of HIV per year across the same period; a vastly disproportionate number, considering that this racial group comprises 13% of the US population (CDC and Prevention 2011). HIV is the most deadly sexually-transmitted infection (STI) with higher burden of disease and mortality than Chlamydia, Gonorrhea, Syphilis, Trichomoniasis, Human Papilloma Virus (HPV), Hepatitis B (Hep B), and Herpes Simplex Virus (CDC and Prevention 2004, CDC and Prevention 2006, Wasley, Finelli et al. 2007, CDC and Prevention 2011, CDC and Prevention 2012, CDC and Prevention 2013).

The extensive impact of an increase in HIV incidents particularly is underscored by the infectious nature of HIV. Since 1983, when the disease was first discovered, the public health efforts to quell its impact have been largely unsuccessful, leading to a rise in HIV infection spread in communities at an epidemic level. Modern antiretroviral treatments were subsequently developed in the early 2000's. The launch of prophylactics (PrEP and PEP) and antiretroviral treatments has enhanced our ability to treat or even prevent HIV infections. The scientific evidence is clear that, when one partner has an STI, or is uncircumcised, this risk for contracting HIV is rises to 1 infection per 10 heterosexual acts. This risk is magnified to 1 infection per 3

acts involving anal sex (Powers, Poole et al. 2008, Bowleg, Teti et al. 2011, Patel, Borkowf et al. 2014).

STIs have an additive effect on rates of contracting HIV (Røttingen, Cameron et al. 2001), especially among African American women and MSM. It is important to highlight the possible pathways through which these risks for new infections and persistence of this epidemic intersect, leading to high rates of HIV/STI incidents within sexually active, intimate relationships. It is therefore important to examine how these phenomena intensify each other (Sexton, Garnett et al. 2005).

One of the most common modes of transmission of new HIV infections among African American women is via heterosexual contact (CDC and Prevention 2011). For African American women, there is an increased risk for HIV among those with a history of intimate partner violence (IPV) and abuse (Singer 2000). In a meta-analysis of 28 studies across 16 countries, Li and colleagues (2014) reported finding that experiences of any type of intimate partner violence IPV led to 1.28 times increase in relative risk for HIV infection in women. Of note, a combination of sexual and physical IPV experiences resulted in double the increase in relative risk for HIV infection among women. In such couples, serodiscordant status, i.e. where one partner is HIV+ while the other is HIV-, can magnify the risk of contracting HIV/STIs. In a meta-analysis of 50 prospective studies of sexual behaviors and HIV transmission among serodiscordant couples receiving antiretroviral therapy (ARTs), researchers reported that among those couples not receiving ART, there was a relative risk of 9 infections per 100 sexual acts. When these non-ART couples were compared to those receiving ART, ART use was associated with a 91% decrease in per-partner HIV incident rate (Baggaley, White et al. 2013). Similarly, in a meta-analysis of 25 studies of condom effectiveness in reducing HIV transmission among

heterosexual serodiscordant couples, Giannou, Tsiara et al. (2016) found that consistent condom use among non-infected partners reduced HIV transmission by 70% compared to those who never or intermittently used condoms while having sex with their HIV infected partner. These findings underscored the increased risk that serodiscordant couples face for HIV/STI risk when condom use is not consistent. While findings from the meta-analyses of 103 studies provides us with a better understanding of the factors driving the epidemic at large, the specific role these factors play among African American women is not well understood. Of the 103 studies referenced above, only 6 of studies examined risk factors among African Americans (4 studies from the 1980's did not report race-ethnicity information). Of those, 5 examined risks among heterosexual African American serodiscordant couples as a part of a larger sample of heterosexual serodiscordant couples but reported observational and/or correlational findings. The one remaining study examined the risk among African American serodiscordant couples, was the parent study for this dissertation (i.e. Project EBAN).

Aside from opting into antiretroviral therapy, researchers have highlighted other factors such as relationship dynamics involving dependency between partners for drugs and money as well as socio-cultural norms and the ability to negotiate safe sex and drug use practices, that further increase risk for HIV spread (Misovich, Fisher et al. 1997, Latkin and Knowlton 2005, Bowen, Williams et al. 2006, Seal, Eldrige et al. 2007, Jiwatram-Negrón and El-Bassel 2014, El-Bassel, Davis et al. 2019, (Husbands, Kerr et al. 2021). This is of particular importance in relationships with where the woman has experienced intimate partner violence. In such couples, concomitantly, other risk-taking behaviors such as substance use, forced sex with an infected partner, and limited ability to negotiating safe sex practices may further exacerbate HIV incidents (Campbell, Baty et al. 2008, Meyer, Springer et al. 2011). In serodiscordant

relationship, researcher have consistently identified increased difficulties navigating issues related stigma of HIV status disclosure, anxiety and fear related to HIV transmission (e.g. Persson, Ellard et al. 2016, Bourne, Owuor et al. 2017, Siegel, Meunier et al. 2018). Factors exacerbating these difficulties range from poor adherence to ART, lack of social support, and/or psychosocial stressors (e.g. Immigration; Mendelsohn, Calzavara et al. 2015). While attempts to model these interdependences have focused primarily on same-sex couples, researchers have identified alcohol use by both partners and mistrust by one partner can influence rates of sexual concurrency among serodiscordant couples (Belus, Baucom et al. 2020), or how changes in the depression and anxiety in the HIV positive partner have direct effects on the quality of life of the HIV negative partner (Mustanski, Starks et al. 2014, Bagheri, Taheri et al. 2019). Recent attempts to examine possible pathways within the relationship that can impact HIV risk have identified the role of dyadic processes of supportive or negative coping (Martins, Canavarro et al. 2021). Specifically, Martins, Canavarro et al. (2021) highlighted the impact dyad-level supportive coping with HIV serostatus related stressor has a cross-partner effect, where in greater coping ability between partners was associated with increased cohesion, relationships satisfaction, and adjustment in the couple. Despite these attempts to identify mechanisms and pathways via which relationship dynamics impact HIV/STI infections, to date there have two studies: the dissertation parent study (EBAN) and EBAN 2 (Wyatt, Hamilton et al. 2020), examining these mechanisms among heterosexual African American serodiscordant couples.

In an attempt to address these disparities among African American serodiscordant couples, the parent study (i.e. Project EBAN) provided a culturally informed couple-focused HIV/STI risk reduction intervention. This 8-session couple-focused intervention was informed by social cognitive theory, relationship oriented ecological framework and Afrocentric

paradigms which targeted changes in multilevel risk and protective factors associated with HIV/STI risk reduction. This was compared to an individual-focused, health promotion intervention which targeted knowledge regarding heart disease, hypertension, stroke and certain cancers, and behavioral skills to address wellness outcomes. Both interventions were provided in the same number, type, duration, and sequencing of sessions. The EBAN intervention was able to reduce sexual-risk behaviors among couples, a relationship that was mediated by condoms-use intention, self-efficacy, negotiating self-efficacy, relationship satisfaction, and safer sex communication (Jemmott III 2008, El-Bassel, Jemmott et al. 2010, El-Bassel, Jemmott et al. 2016). While these findings underscore the efficacy of the intervention in increasing safe sex behaviors, the trial did not influence HIV/STI incident and failed to reduce number of concurrent partners. The complexity of these phenomena underscores the difficulties in creating, implementing, and understanding why, when, and for whom interventions are effective. In a follow-up study in Oakland and Los Angeles, led by Wyatt, Hamilton et al. (2020), the researchers found that while the intervention was successful in increasing overall condom use, these gains were lost by the 3 month follow-up. This was in part due to the lack of basic needs such as housing, food, and transportation preventing couples from attending and adhering to the intervention as well as high drop-outs rates due to substance abuse, incarceration and homelessness.

The compounding effects of STIs on HIV transmission, and the role of the interpersonal practices, and the limits of interventions to address these issues underscores the need to understand where these risks interact with the high rates of HIV/STI among African Americans. Disproportionate risk for these negative outcomes among racial minorities has been associated with environmental disparities such as poverty, concentration of HIV/STIs among sexual

networks, lack of access to appropriate health care services, unemployment, diminished educational opportunities and need housing assistance, food insecurity, high crime, and inadequate public policies (Rhodes 2002, Rhodes, Singer et al. 2005, Blankenship, Friedman et al. 2006, Riley, Gandhi et al. 2007, Shubert and Bernstine 2007, Montaner, Lima et al. 2010, Strathdee, Hallett et al. 2010, Rhodes, Wagner et al. 2012, Baral, Logie et al. 2013, Loosier, Haderxhanaj et al. 2020). Of note, in a study by Ransome, Kawachi et al. (2016), authors found that higher income inequality, socioeconomic deprivation, and racial concentration predicted HIV diagnoses, with neighborhoods with higher concentration of black individuals predicted higher late HIV diagnosis and disease concentration.

While it is difficult to find a causal association between environmental disparities and HIV/STI incidents, researchers examining the role of social determinants of HIV/STI among African American women highlight potential pathways through which these disparities moderate the risk for HIV/STI incidents (Sharpe, Voûte et al. 2012). Two longitudinal observational studies examining county- and census-tract-level associations between social determinants and HIV diagnosis among African Americans have identified potential moderators of HIV/STI incidents (Gant, Lomotey et al. 2012, Gant, Gant et al. 2014). Researchers found that among heterosexual African American men, rates of HIV varied with increases in housing vacancy, lower educational attainment, and higher number of non-married individuals in their census tract over a 4-year period (Gant, Gant et al. 2014). An opposite trend in HIV incidents among these men was observed in areas where there was a greater number of unemployed and married individuals. For African American women, an increase in incidents of HIV was observed at the county-level over 2 years in areas with greater income inequality and higher number of unmarried individuals (Gant, Lomotey et al. 2012). A reverse in the trend was observed for those

women residing in counties with a greater proportion of white individuals. These somewhat convergent and divergent findings highlight the differential impact that environmental disparities, have upon HIV/STI incidents among heterosexual African Americans. These data highlight that the concentration of HIV/STIs is not limited to those residing to poor versus affluent communities, or rural versus urban communities, nor is it limited only to racial minorities; it is the combination of these factors. That it is those African Americans residing in urban environments that have a disproportionate level of risk.

Engagement in risky sexual and drug use behaviors can increase harmful relationship dynamics which may be a vulnerability factor for the contraction of HIV/STIs. It is therefore possible that harmful relationship dynamics could be one pathway through which individual risk behaviors increase the likelihood of HIV/STI incidence. These pathways are further complicated by the interaction of environmental disparities with individual risk and interpersonal practices (**Figure 1.** ***Conceptual Model***).

The syndemic theory by Singer (2000) attempts to explain the interaction between multiple pathways of disease risk, to explain how the combination of: 1) disease concentration, 2) disease interaction, and 3) the role of co-occurring, mutually reinforcing large-scale processes, maintains an epidemic. This theory can be used to look at HIV/STI risk by modeling social and ecological phenomena. The syndemic theory of HIV/STI risk proposes that HIV/STI incidences are a result of dynamic interaction between individual, interpersonal, and environmental problems (Singer and Clair 2003, Singer, Bulled et al. 2012, Talman, Bolton et al. 2013, Batchelder, Gonzalez et al. 2015, Tsai 2018).

There is a serious deficit in the literature on modeling of HIV/STI incidents using this theory. The complex interaction of these pathways in explaining HIV/STI incidence highlights

the difficulties of testing this theory. A review of 40 studies examining the syndemic theory of HIV risk reported that studies lacked modeling of multilevel indicators of HIV/STI risk and a failure to analyze interactions between HIV/STI risk (Tsai and Burns 2015). The failure to analyze these interactions has hampered the close grained understanding of the phenomenon. A critical analysis and updated review of 71 studies testing syndemic theories of HIV risk yielded further methodological and statistical limitations in the literature. Notably, these studies were using observational, retrospective, and cross-sectional designs and used sum score indicators for syndemic risk, instead of relying on prospective longitudinal studies that use a dynamic measure of syndemic risk (Tsai, Mendenhall et al. 2017).

The impact that complex multiple interlinked systems can have on the health of African American communities will be examined. The main outcomes of this dissertation will be to investigate the multilevel causal mechanisms that lead to new infections among heterosexual African American females in serodiscordant relationships residing in urban areas. I will make recommendations to improve the methodological and statistical approaches to the syndemic study of HIV risk. Ultimately, the goal is to propose a robust model that can be used to refine the targets of public health interventions and policy programs to reduce HIV/STI incidence among heterosexual African Americans in the US.

Had I the command of you as well as of myself, Meno, I would not have enquired whether virtue is given by instruction or not, until we had first ascertained "what it is." But as you think only of controlling me who am your slave, and never of controlling yourself,-such being your notion of freedom, I must yield to you, for you are irresistible. And therefore I have now to enquire into the qualities of a thing of which I do not as yet know the nature.

1.1 Research Questions

This dissertation seeks to incrementally explain the impact of individual, interpersonal, and environmental levels of risk upon HIV/STI incidents: **AIM 1)** Examine the trends in individual sexual behaviors and their association with HIV/STI incidence, **AIM 2)** Examine the role of relationship dynamics as a direct cause and indirect mediator of the relationship between individual sexual behavior and HIV/STI incidences, and **AIM 3)** Examine the differential impact of environmental disparities such as poverty, HIV/STIs concentration, lack of access to: health care services, employment, education, housing assistance, and food; along with high crime rates, and lack of protective policies regarding these issues, upon the relationship between relationship dynamics and individual behaviors and HIV/STI incidence. I used analytic methods that can model these heterogeneous pathways within and across each level of risk.

1.2 Hypotheses

1.2.1 AIM1:

I expect that there will be 3 typologies of sexual risk behaviors, and that those in the high sexual risk behavior typology will have the highest risk for new infection (Fig 1a).

1.2.2 AIM 2:

I expect that the development of stronger relationship dynamics (e.g. relational dependencies and safe sex norms) will partially explain the direct and indirect relationship between individual behavioral typologies and HIV/STI incidences (Fig 1b).

1.2.3 AIM 3:

I expect that the indirect relationship between individual behavioral typologies and relationship dynamics to HIV/STI incidence will be moderated by environmental disparities, such that the relationship between individual- and interpersonal-levels of risk will be stronger for

those residing in areas with greater concentration of social determinants of health, than those residing in lower concentration (Fig 1c).

Chapter 2: Method

I used data from a multisite couple-based HIV/STI prevention intervention study among African American serodiscordant couples living in 4 metropolitan areas between 2003-08 (New York, Philadelphia, Atlanta, and Los Angeles; **Project Eban**; n = 535 couples (El-Bassel, Jemmott et al. 2010). Environmental disparities indicators were gathered from governmental surveillance reports in these cities. Assessments were conducted at baseline (T1), immediately post-intervention (T2), 6 months (T3) and 12 months (T4) post-intervention.

2.1 Sample

To participate in the parent study EBAN (El-Bassel, Jemmott et al. 2010), participants were included if both partners independently endorsed: 1) being in a relationship for at least 6 months before the study; 2) an intent to remain in an intimate relationship for 12 months after start of study; 3) aware of each other's HIV status and 4) do not plan on relocating during the study. Furthermore, at least one partner endorsed: 5) having unprotected sex in the past 90 days before study; 6) self-identifies as African American; 7) a lack of intention to become pregnant in the next 18 months. Finally, only one member of the couples needed to be HIV positive and has known their status for at least 3 months before start of study.

Couples were excluded from the parent study if both partners endorsed: 1) participation in any HIV sexual-risk reduction intervention 12 months prior to start of study. Furthermore, couples were excluded if at least one partner endorsed: 2) an inability to receive mail at a residential address; 3) a history of severe physical or sexual abuse in the past 12 months; 4) being unable or unwilling to commit to study participation through the end; and 5) is not able to give informed consent in English. Finally, couples were excluded if either partner met criteria for

significant mental, physical, or neurological impairment based on the Mini Mental Status Examination and Quick Test, such that it hindered their ability to effectively participate in the study.

2.2 Procedures

Self-report assessments were conducted at baseline, immediately postintervention, and 6 and 12 months postintervention using an Audio Computer-Assisted Self-Interview (ACASI) for self-report questions. This is a user friendly self-guided platform for data collection, using a computer system. Prior research examining the reliability of various assessment methods to capture sexual behaviors, has identified that the use of ACASI as an ideal assessment procedure in populations engaging in high risk behaviors in both local and international settings (Macalino, Celentano et al. 2002, Morrison-Beedy, Carey et al. 2006, Van Der Elst, Okuku et al. 2009). The use of an ACASI has been shown to yield higher rates of survey completion, accuracy of responses, and has the additional benefit of providing accessibility to questionnaires for those with limited literacy (NIMH Collaborative Group 2007). At each time point, partners independently provided biological specimens for HIV/STI assessment.

2.3 Biological Data

Specimens for biological test of HIV/STI were self-collected from each partner. Women provided two vaginal swab specimens. Men provided urine specimens. These specimens were assayed at the Emory University pathology laboratory for chlamydia trachomatis and Neisseria gonorrhoeae using the Becton Dickinson Probe ET Amplified DNA Assay (Chan, Brandt et al. 2000) and for trichomonas vaginalis using a noncommercial real-time polymerase chain reaction assay. Those couples with positive STI test result were provided antimicrobial treatment and risk-reduction counseling as per CDC recommendations (Barrow, Ahmed et al. 2020).

STI incident was defined as a positive STI test result at any of the three assessments conducted after the intervention. An HIV/STI incident was defined as the new occurrence of an STI or HIV infection by the last assessment point during the study. Subsequently, couples were considered to have had an incident if either partner had an HIV/STI incident.

2.4 Individual Data

Self-reported data on sociodemographic characteristics, substance use, symptoms of depression and PTSD, mental health and substance use treatment history, and sexual behaviors were collected using the ACASI at each time point.

2.4.1 Sociodemographic characteristics:

Included assessment of age, education, marital status, employment status, income, type of health insurance, and incarceration history. HIV positive partners were asked to report on length of diagnosis, CD4 lymphocyte count, viral load, and adherence to antiretroviral treatment.

2.4.2 Substance use:

Was assessed using the CAGE questionnaire (Ewing 1984) and Texas Christian University Drug Screen (TCUDS; Peters, Greenbaum et al. 2000) to identify lifetime alcohol dependence and history of drug dependence, respectively. A score greater than or equal to two on the CAGE and greater than or equal to three on the TCUDS indicate alcohol and drug problems, respectively.

2.4.3 Mental Illness Symptoms:

Depression symptoms in the past one week were assessed using a modified Patient Health Questionnaire using 6-items (Kroenke, Spitzer et al. 2001). PTSD symptoms in the past one month were assessed using the 17-item PTSD Checklist (Weathers, Litz et al. 1993). Mental

health and substance use treatment history was assessed by asking participants about history of admission and duration of stay at an inpatient or residential drug treatment program.

2.4.4 Sexual behaviors:

Were assessed using a timeline follow-back method and assessed number of condom-protected vaginal and anal intercourse acts, number of unprotected oral, vaginal or anal intercourse acts, instances of sex under the influence of drugs or alcohol, and consistent condom use with study partner and incidence of concurrent partners in the past 90 days at baseline and follow-ups, and in the past 60 days at immediate postintervention.

2.5 Relationship/Partner Data

Questions regarding relationship characteristics were independently assessed using the ACASI. Congruent responses were coded if both partners endorsed similar characteristics. Participants were asked about the length of relationship, quality of relationship (e.g. "In the past 3 months, how often did you have a desire for sex with your study partner?"), and cohabitation status with the study partner.

2.5.1 Relationship dependences:

Were assessed using 7-items that asked about frequency of discussion of sexual behaviors in the relationship using a 5-point Likert-scale ranging from *0 times* to *8 or more times*. Sample questions include, "In the past 3 months, how frequently have you discussed oral sex as an alternative to vaginal or anal sex?" and "In the past 3 months, how frequently have you discussed how to prevent infection of HIV?". An additional 7-items were used to assess for difficulties negotiating condom use in the relationship, using a 5-point Likert-scale ranging from *Definitely No* to *Definitely Yes*. Sample questions included, "Can you insist on condom use every time even when you are under the influence of alcohol or drugs?" and "Can you insist on condom use if

your study partner does not want to use one?". A sum score of these items will indicate the level of dependency between partners in the relationship.

2.5.2 Safe Sex Norms:

Each partner was also asked about their attitudes towards serodiscordant couples' behaviors. Using an 8-item measure with 4-point Likert-scale ranging from *None* to *All.* Sample questions include, "How many couples with different HIV status do you think use either a male or female condom every time they have vaginal sex?" and "How many couples with different HIV status do you think take responsibility for protecting each other from HIV and STDs?". Higher values on the sum score indicates positive safe sex norms.

2.6 Environmental/Surveillance Data

Governmental data on sociodemographic characteristics, rates of reported HIV, AIDS, and notifiable STIs, rates of educational attainment, unemployment rates, housing characteristics, violent and non-violent crime rates, substance use disorder and harm reduction programs, number of individuals on government assisted food programs (e.g. SNAP), and policy indicators (e.g. laws regarding criminalization of sex trading and substance use) were retrieved from government databases in the four targeted US cites.

A team of six graduate level research assistants collected these data from governmental websites for the parent study duration between 2003 to 2008, across four cities, Atlanta, GA, Los Angeles, CA, New York, NY, and Philadelphia, PA. Spatial data were collected at the most granular level (e.g. census tract) and aggregated up to city- or state-level depending on the availability of data. Similarly, temporal data were collected at the most granular level (e.g. months) and aggregated for year or decade for some demographic variables derived from the US census, depending on availability of data. All rates of environmental disparities were defined by

the rate of incident per 100,000 residents. Spatial-temporal data was linked to individual and couple level responses based on site of recruitment and year of assessment.

2.6.1 HIV/STI Rates

Reportable HIV, AIDS, and STIs were derived from the Sexually Transmitted Disease Surveillance report from the Centers of Disease Control and Prevention for the years of assessment (2003-2008) in each of the four cities in the U.S. (CDC and Prevention 2008) This included indicators of the number of HIV positive cases, number and rate of AIDS cases, rates of chlamydia, gonorrhea, syphilis and chancroid cases. Due to limits in data collection via CDC surveillance systems prior to the 2009 renewal of the Ryan White HIV/AIDS Program Legislation, we were only able to gather data for reported rates of HIV/STIs at the state level. The rate of each of the diseases is defined by incident per 100,000 individuals in population.

2.6.2 Education and unemployment

The educational attainment data was gathered from the annual American Housing Survey and American Community Survey by the U.S. Census Bureau (2009). We extracted data on the number of individuals over the age of 25 who had: 1) less than a high-school education, 2) graduated high-school, 3) had some college, but did not graduate, 4) received a bachelor's degree, and 5) received a post-graduate degree. We gathered information on the number of individuals actively unemployed between the ages of 25 to 64 from the Bureau of Labor Statistics, from the US Department of Labor. Data on both educational attainment and unemployment rate were collected at the city-level, accrued annually.

2.6.3 Housing characteristics

Data on housing characteristics were gathered from the American Community Survey by the U.S. Census Bureau. We extracted data on the number of single parent households and the

number of families living under the nationally defined poverty line between 2003 – 2008. The single parent households were calculated by adding the data from the number of female-led households, with no spouse present, and male-led households, with no spouse present. The number of households living in poverty were estimated from the total number of people between the ages of 18 to 64 living below the national poverty line as defined by Annual Poverty Status from the U.S. Census Bureau (Fontenot, Semega et al. 2018).

2.6.4 Crime and incarceration

To assess the frequency of criminal justice involvement in these cities, we collected information on the reported rates of arrests and incarceration made for violent and non-violent crimes from the FBI national crime reporting database (FBI Report 2003, Report 2004, Report 2005, Report 2006, Report 2007, Report 2008). We gathered annual city-level rates and raw number of arrests made for violent crimes, including murder, rape, robbery, aggravated assault and non-violent crimes, including burglary, larceny-theft, motor vehicle theft from the annual FBI Uniform Crime Reporting Program. We gathered additional information on rates of criminal justice involvement in the community from the U.S. Bureau of Justice Department on the number of individuals under community supervision, number of people incarcerated in prisons, and number of people incarcerated in jails by each metropolitan statistical area. Data on the number of individuals incarcerated in prisons was derived from the from Bureau of Justice Statistics' *Prisoners under the jurisdiction of State or Federal correctional authorities*, aggregated at the state- and jurisdiction-level, annually. Rates of individuals in jail were based on the inclusion of the 50 largest local jails in each metropolitan jurisdiction and their rated capacity, average daily population, and total number of inmates.

2.6.5 Substance Use Treatment

To assess the availability and utilization of substance use treatment services in these cities annually, we collected information on the number of individuals who sought substance use treatment by the type of substance. Data was gathered from the Substance Abuse and Mental Health Service Administration (SAMHSA) *Treatment Episode Data Set (TEDS),* for years between 2003 to 2008 by each state (i.e. Georgia, California, New York and Philadelphia) (SAMHSA 2006, SAMHSA 2016). Admissions was defined per 100,000 population aged 12 and older. Substance use treatment services included admission to outpatient substance use clinics, day programs, substance use clinics, and medically assisted treatment providers. The substance use treatment was limited to treatment for alcohol, marijuana, cocaine, heroin, methamphetamine/amphetamine and other opiates use disorders. Marijuana/hashish—Includes THC and any other cannabis sativa preparations. Other amphetamines include amphetamines, MDMA, phenmetrazine, and other unspecified amines and related drugs. Other opiates and synthetics include buprenorphine, codeine, hydrocodone, hydromorphone, meperidine, morphine, opium, oxycodone, pentazocine, propoxyphene, tramadol, and any other drug with morphine-like effects, and other includes diphenylhydantoin/phenytoin, GHB/GBL, and ketamine. Polydrug use was identified by the client's primary, secondary and tertiary substance problems, which is associated with route of administration, frequency of use, age at first use, and the TEDS Supplemental Data Set items on detailed drug codes by state.

Data on access to harm reduction programs was collected by counting the number of syringe exchange programs present in each state. harm reduction programs were included if they provided syringe exchange and psychosocial services while under regulation by SAMSHA's

Harm Reduction Coalition. In 2003, for example, this included one syringe exchange program in Georgia, 25 in California,12 in New York, and two in Pennsylvania.

2.6.6 Food programs

To assess for indicators of food insecurity we gathered annual state-level information on the Supplemental Nutrition Assistance Program (SNAP) via the U.S. Department of Agriculture's Food and Nutrition Services (Food and Services 2020). Data was gathered on the annual budget allocated by the federal government per state for SNAP as well as the number of families actively receiving SNAP benefits annually in each state. We further gathered sociodemographic characteristics including age, sex, employment status, highest educational attainment, and race/ethnicity of SNAP recipients.

2.6.7 Policy Indicators

To assess the state-level policies related to aforementioned environmental disparities across housing, sexual health, substance use treatment, and sex work, we conducted a scoping review of each state legislature body between 2003 to 2008 across Georgia, California, New York and Pennsylvania. Building on the methods presented in Panagiotoglou, Olding et al. (2018), we identify the presence of state-level policies during the course of this study (2003-2008) that provided legislative protection and enforcement of affordable housing laws, policies regarding contraceptive coverage, presence of needle exchange programs, and criminalization of sex work.

2.7 Data Analyses

To elucidate the pathway in **AIM 1** I used Latent Transition Analysis to identify which changes in co-occurring sexual and drug use behaviors (i.e. typologies) over time lead to new infections (Fig. 2). For **AIM 2**, I used a Parallel Process Latent Growth Model (PPLGM) to map

the parallel development of relationship dynamics and individual risk typologies over time and answer how the development of relationship dynamics affect subsequent trajectories of individual risk behaviors and HIV/STI incidence (Fig. 4). For **Aim 3**, I built on the Parallel Process Latent Growth Model and test how these developing relationships between individual and interpersonal factors vary based on the level of environmental disparity (Fig. 5).

2.7.1 Data Preparation

To prepare the data for analysis, I first linked the data from the parent study EBAN, which included the biological, individual, and relationship data, to the environmental data collected from governmental websites. This was done by matching the environmental data to one of the four (Atlanta, GA, Los Angeles, CA, New York, NY, and Philadelphia, PA) recruitment sites. Furthermore, I matched the environmental data by time, ranging the duration of the study between 2003 to 2008. The final analyses include findings for all the female participants.

2.7.2 Average slope of state level number of people diagnosed with HIV:

HIV density was defined as the average change in the number of people with HIV from 2004 to 2008 at the state-level. For analyses, these rates of change were binned into rates of change at the 16th (change in number of people diagnosed with HIV = -830), 50th (change in number of people diagnosed with HIV = -61), and 84th (change in number of people diagnosed with HIV = 920) percentiles. For models mapping transition status from Time 2 to Time 3, the bootstrap confidence intervals did not converge, so rates of change were binned into dichotomous bins where rates of change of HIV density increased or decreased over time.

2.7.3 Average slope of city level number of people diagnosed with AIDS:

AIDS density was defined as the average change in the number of people diagnoses with AIDS from 2004 to 2008 at the city-level. For analyses, these rates of change were binned into rates of change at the 16th (change in number of people diagnosed with AIDS = -240.67), 50th (change in number of people diagnosed with AIDS = -15.67), and 84th (change in number of people diagnosed with AIDS = 126.33) percentiles, ranging from decreases (16th %tile) to increases (84th %tile) in cases.

2.7.4 Average slope of city level number of people diagnosed with Chlamydia:

Chlamydia density was defined as the average change in the number of people diagnosed with Chlamydia from 2004 to 2008 at the city-level. For analyses, these rates of change were binned into rates of change at the 16th (change in number of people diagnosed with Chlamydia = 233), 50th (change in number of people diagnosed with Chlamydia = 3136.33), and 84th (change in number of people diagnosed with Chlamydia = 13216.33) percentiles, ranging from small (16^{th} %tile) to very large increases (84^{th} %tile) in cases.

2.7.5 Average slope of city level number of people diagnosed with Gonorrhea:

Gonorrhea density was defined as the average change in the number of people diagnosed with Gonorrhea from 2004 to 2008 at the city-level. For analyses, these rates of change were binned into rates of change at the 16th (change in number of people diagnosed with Gonorrhea =-383.67), 50th (change in number of people diagnosed with Gonorrhea = 148.5), and 84th (change in number of people diagnosed with Gonorrhea = 1505) percentiles, ranging from decreases (16th %tile) to very large increases (84th %tile) in cases.

2.7.6 Average slope of city level number of people diagnosed with Syphilis:

Syphilis density was defined as the average change in the number of people diagnosed with Syphilis from 2004 to 2008 at the city-level. For analyses, these rates of change were binned into rates of change at the 16th (change in number of people diagnosed with Syphilis=-4.33), 50th (change in number of people diagnosed with Syphilis= 103.67), and 84th (change in number of people diagnosed with Syphilis= 202) percentiles, ranging from small decreases (16th %tile) to very large increases (84th %tile) in cases.

2.7.7 Average slope of city level number of people diagnosed with Chancroid:

Chancroid density was defined as the average change in the number of people diagnosed with Chancroid from 2004 to 2008 at the city-level. For analyses, these rates of change were binned into rates of change at the 16th (change in number of people diagnosed with Chancroid= -1), 50th (change in number of people diagnosed with Chancroid= 0), and 84th (change in number of people diagnosed with Chancroid= .33) percentiles, ranging from small decreases (16th %tile) to large increases (84th %tile) in cases.

2.7.8 Average slope of state level percent of persons living below poverty level:

Poverty level was defined as the average change in the percent of people living below the poverty level from 2004 to 2008 at the state-level. For analyses, these rates of change were binned into rates of change at the 16th (change in percent of people living below poverty level = -6.7%), 50th (change in percent of people living below poverty level = 3.3%), and 84th (change in percent of people living below poverty level = 16.7%) percentiles, ranging from small decreases (16th %tile) to increases (84th %tile) in poverty.

2.7.9 Average slope of city level number of violent crimes:

Violent crime rate was defined as the average change in the number of violent crimes from 2004 to 2008 at the city-level. For analyses, these rates of change were binned into rates of change at the 16th (change in number of violent crimes = -1200.67), 50th (change in number of violent crimes = -.544), and 84th (change in number of violent crimes = 111.67) percentiles, ranging from large decreases (16th %tile) to increases (84th %tile) in cases.

2.7.10 Average slope of state level number on individuals under community supervision

Community supervision rate was defined as the average change in the number of individuals under parole per 100,000 residents from 2004 to 2008 at the state-level. For analyses, these rates of change were binned into rates of change at the 16th (change in number of individuals on parole = -6.33), 50th (change in number of individuals on parole = -2.67), and 84th (change in number of individuals on parole = 1.3333) percentiles, ranging from decreases (16th %tile) to increases (84th %tile) in cases.

2.7.11 Average slope of state level number on individuals incarcerated

Incarceration rate was defined using two indicators: a) the average change in the number of inmates held in jail from 2004 to 2008 at the city-level, and b) the average change in the number of inmates held in prisons under state or federal jurisdiction from 2004 to 2008 at the state-level. For analyses, these rates of change were binned into rates of change at the 16th (change in number of inmates in jail = -212.33; change in number of inmates in prison = -758.67), 50th (change in number of inmates in jail = 37.67; change in number of inmates in prison = -145.33), and 84th (change in number of inmates in jail = 171.67; change in number of

inmates in prison = 1347.6667) percentiles, ranging from large decreases (16th %tile) to large increases (84th %tile) in number of inmates.

2.7.12 Average slope of state level substance use treatment utilization:

Substance use treatment utilization was defined as the average change in the number of individuals per 100,000 above the age of 12 seeking substance use treatment between 2004 to 2008 at the state-level, after adjusting for age, gender, and race/ethnicity. For analyses, these rates of change were binned into rates of change at the 16th (change in number of individual per 100,000 receiving substance use treatment= -14.33), 50th (change in number of individual per 100,000 receiving substance use treatment = -2.67), and 84th (change in number of individual per 100,000 receiving substance use treatment = 56.33) percentiles, ranging from decreases (16th %tile) to increases (84th %tile) in seeking substance use treatment.

2.7.13 Laws Regarding Contraceptive Coverage:

Contraceptive coverage was defined as the presence or absence of laws providing public funding from access to Family Planning Services and contraceptives between 2004 to 2008 at the state-level.

2.7.14 Latent Transition Analysis:

A Latent Transition Analysis a method of examining stability and changes in group membership over time. Group membership is inferred from commonalities across multiple variables, such that group membership or classes becomes a derived latent construct (Lanza, Bray et al. 2012). To best understand the utility of Latent Transition Analysis, we must understand latent classes.

A latent class is a grouping of individuals based on an unmeasured unobservable construct. These classes or typologies are derived by subgrouping individuals using patterns of responses to multiple measurable constructs or behaviors. The subsequently derived latent classes are an exhaustive and inclusive categorization or subgrouping of individuals in a given sample. Therefore, in an LTA, I examined the movement of individuals between latent classes over time and thus estimating how membership or typologies changed based on changes in patterns in the underlying latent construct. The benefit of categorizing people based on patterns of behaviors using latent class-based methods, is that we are able to derive unique and informative subgroups based on multiple common characteristics rather than apriori group assignment or post-hoc measurement on a specific outcome variable (Nylund-Gibson, Grimm et al. 2014).

In this dissertation, such an exploration into the similarity in patterns of sexual risk behaviors would not be sufficiently detected in a simple dichotomization of sexual risk behaviors as individuals would be slotted into groups that are defined by a single behavior instead of patterns of behaviors. Therefore, to identify which changes in co-occurring sexual risk behaviors (i.e. typologies) over time lead to new HIV/STI incident (**AIM 1**), I used a Latent Transition Analysis (LTA).

Figure 2 provides a visual representation of the proposed latent transition analysis to test AIM 1 (read top-down). Specifically, I first conducted a latent class analysis of sexual risk behaviors at each time point to identify empirically derived patterns in these behaviors. Specifically, I included: a) unprotected vaginal sex, b) unprotected anal sex, c) sex outside the relationship, d) oral sex, e) engaging in sex for trade, f) treatment of STI, and g) Hepatitis C Status as observable indicators of the underlying latent construct of *HIV/STI risk*. Using these 7

variables, I derived latent classes at the four assessment points in the study (i.e. baseline, immediately postintervention, and 6 and 12 months postintervention). This is depicted in Fig. 2 as [A T1…G T1] through [A T4…G T4]. Next, I assessed for measurement invariances of the derived classes and status over time. Once measurement invariance was established, I derived transitional probabilities for each participant across classes over time. This provided information regarding change in class membership between two time points (e.g. baseline (T1) to immediately postintervention (T2); 6 months (T3) to 12 months (T4) postintervention). Results from this analysis allowed me to identify significant changes in sexual risk behavior classes as well as identify which, if any, classes have stable or unstable membership over time. These class memberships and subsequent changes in these memberships, derived as posterior probability of class membership, is regressed upon HIV/STI status at 12 months postintervention, to determine whether changes in classes membership predicts the likelihood of HIV/STI incident.

2.7.15 Latent Growth Mixture Model

To assess the indirect and direct impact of relational dynamics upon HIV/STI incidents (AIM 2), I first needed to model the relationship dynamics, using a Latent Growth Mixture Model (LGMM) analysis. Specifically, I defined relationship dynamics as a summed combination of relationship dependences and safe sex norms within the relationship. Building on our understanding of latent classes, a Latent Growth Mixture Modeling allows us to map empirically derived trajectories of change across different latent classes over time. Unlike the Latent Transition Analysis, which examines changes in class membership over time, a LGMM allows us to model changes in individual characteristics within and across classes (Nylund-Gibson, Grimm et al. 2014). This method provides the added benefit of being able to account for

multilevel data, which a traditional LTA analysis does not allow. Considering the high expected correlation in responses to changes in relationship dynamics between partners in a relationship, a method that is highly tolerant of interclass correlations is needed. A Latent Growth Mixture Model is best suited for this as the statistical assumption in this analysis is that the observations are dependent and expected to have high levels of interclass correlations (Jung and Wickrama 2008).

Figure 3 provides a visual representation of the proposed LGMM analysis to identify trajectories of relationship dynamics (read top-down). I modeled the changes in relationship dynamics over time by first identifying unique latent classes and then mapping the trajectory of these classes across the four assessment points. Using a fixed intercept and random slope model, I identified distinct classes at baseline and then allowed for varying possibilities of change in trends over time in the trajectories. The outcome of this analysis yielded a number of unique trajectories of relationship dynamics across dyads. It will be these trajectories of change that will be used as mediators in AIM 2.

2.7.16 Parallel Process Latent Growth Model

For AIMS 2 and 3, I used a Parallel Process Latent Growth Model. Similar in principle to Latent Class Analysis, Latent Transition Analysis, and Latent Growth Mixture Model, this approach allows me to estimate the magnitude of change in latent groups and latent trajectories over time. A Parallel Process Latent Growth Model has the added benefit of allows us to test for the impact of concurrent relationships between processes over time (Cheong, MacKinnon et al. 2003). For this dissertation, that relationship is the concurrent change in sexual risk behaviors as relationship dynamics changes.

The interrelationship between changes in latent constructs over time thus allows us to examine how the changes in relationship dynamics has an impact on the changes in sexual risk behaviors. This also allows us to see how this interrelationship impacts HIV/STI incidents. Therefore, for AIM 2, I combined the models in figure 2 and 3 by superimposing the figures on top of each other, to examine how the intercept and change in slope of sexual risk behaviors is mediated by the intercept and change in slope of relationship dynamics. Following this, I then estimated how the change in class membership over time (i.e. latent status) for both sexual behaviors and relationship dynamics predict HIV/STI incident at 12 months post intervention. A truncated visual representation of this analysis can be seen in red in figure 4.

Building on this proposed model in figure 4, I used a similar model to understand the moderating impact that environmental disparities may have upon the relationships outlined in AIMS 1 and 2. This was achieved by including a multinomial or binominal indicator for each environmental disparities as a moderator in the analysis. This moderator of mediator analysis was used to identify under which conditions does the relationship between sexual and drug use behaviors, and relationship dynamics, predict HIV/STI incidents. This was tested by regressing the environmental disparities indicators upon the latent status membership for sexual risk behaviors and relationship dynamics. A truncated visual representation of this can be seen in red in figure 5.

2.7.17 Power Analysis

Based on our full model (Fig 1), there are 39 manifest variables and 780 data points. I will be estimating the following parameters: 41 betas, 58 variances, and 10 covariances. I conducted a power analysis using procedures advocated by MacCallum, Browne et al. (1996), who compute sample size and power on the basis of the root-mean square error (RMSE). The

latter represents the degree to which the data fit the structural equation model (SEM) proposed. The authors suggest H0: RMSE=.05 vs. Ha: RMSE = .08 to represent a test of close fit. The number for degrees of freedom for our model is 671. Using the an Online program created by Preacher and Coffman (2006), I found that the total number of observations required for 80% power at the 5% level of significance is 125. Assuming an intra-class correlation of .5 between subjects, this corresponds to a sample size of 360 (Doğan and Doğan 2015).

Chapter 3: Results

The final analyses included 535 African American females with an average age of 41.7 (SD = 7.67). A nearly a third of the women had less than a high school education (32.9%; n =176) and 39.1% of them reported being married at the start of the study. A majority of women were unemployed (76.4%; n = 409), made less than $850 a month (71.6%; n = 383), and had health insurance (81.9%; n = 435). Close to half the sample had been previously incarcerated (47.9%; n = 266) and received inpatient substance use disorder treatment (49.7%; n = 266). Of the 535 women, 60.4% (n = 323) were HIV positive, 21.8% (n = 116) had Trichomoniasis, 0.8% (n = 4) had Chlamydia, and 0.2% (n = 1) had Gonorrhea, at baseline. Assessment of posttraumatic stress disorder symptoms (PCL), suggest that there is significant presence of PTSD symptoms, with suggested civilian cut-off score of 30 (Wilkins, Lang et al. 2011), the average severity in this sample (M = 31.26, SD = 13.36) suggest that individuals would benefit from further screening for PTSD disorder. Further details on sociodemographic characteristics can be found in Tables 1 and 3.

3.1 Aim 1

Following guidelines outlined by Ryoo, Wang et al. (2018), I used the 5-step process for conducting a Latent Transition Analyses (LTA). For the first step (Ryoo et al. 2018's Step 0), I conducted separate cross-sectional latent class analyses (LCA) of seven sexual risk behaviors for female participants for each of the four assessment points. To determine the final number of classes from the LCA, I used the following hierarchy of model fit statistical indicators: 1) the smallest Akaike Information Criterion (AIC) value, 2) smallest Bayesian Information Criterion (BIC) value, 3) smallest Sample Size Adjusted Bayesian Information Criterion (SSBIC) value, 4)

significant Bootstrapped Likelihood Ratio test (BLRT), 5) significant Lo-Mendell-Rubin (LMR) test, and 6) entropy values above 0.80 (Nylund, Muthén et al. 2006, Nylund, Asparouhov et al. 2007, Lanza and Bray 2010, Lanza, Bray et al. 2012, Nylund-Gibson and Choi 2018). For the LCA of female participants, fit statistics indicated best model for a five- or six-class solution at Time 1, six- or seven-class solution at Time 2, six- or seven- or eight-class solution for Time 3, and a six-class solution for Time 4. Due to the variability in solutions across time points, I sought to derive a parsimonious model the best explained the underlying latent properties of the sexual risk behaviors. Further examination of the seven- and eight-class solutions yielded newly derived classes that were identified to have similar underlying patterns, but difference only in magnitude. Based on these post-hoc examinations, the decision was made to use a six-class solution to test for latent transition statuses. For fit statistics generated for Step 0, refer to Table 2.

Based on Step 1 of Ryoo et al. (2018), I sought to test for longitudinal measurement invariance in the LTA. The purpose of this step is to assess if the initial derived classes at Time 1 represent the same underlying latent construct at subsequent time points. If measurement non-invariance is found, this would suggest that the latent statuses do not hold the same characteristics over time (e.g., Characteristics of Latent Class 1 at Time 1 are different than those of Latent Class 1 at Time 2). To test for longitudinal measurement invariance, I used a similar model fit procedure as defined above when deciding optimal number of latent classes. Specifically, six-class models with and without measurement invariance were compared on AIC, BIC, and SSBIC, with models that provided the smallest value across these indices being retained. I found that the measurement invariance model converged appropriately while the non-measurement variance model did not converge to provide a solution. Possible sources of non-

convergence could be related to the number of possibilities that an unconstrained model would result in. Specifically, in a 6-class model assuming measurement invariance, there would 1,296 possible latent statuses while a similar model assuming measurement non-invariance (i.e. all latent classes differ across time) there would be 5,184 possible latent statuses to be derived from 535 individuals. Upon running the LTA, assuming measurement invariance, I found that three of the six latent classes did not have any members for multiple time points. Of note, at Time 1, three classes had no members, at Time 2 one class has only 2 members (0.005%) and at Time 3 another class has 7 members (1.5%). This variability suggested that while based on cross sectional model fit statistics, a six-class LTA solution should have been viable, the lack of membership in three of the six classes suggest that there are three stable classes that are repeatedly derived across the four time points, while four- and five-class models do not provide consistent class membership over time. Based on this, I revised step 0 to test the viability of a three-class solution across each time point.

The three classes derived were: 1) Low Sexual Risk (**LSR**; 35.7%; n = 191), 2) Medium Sexual Risk (**MSR**; 5.4%; n = 29), and 3) High Unprotected Sex (**HUS**; 58.9%; n =315; Figure 6). Post-hoc one-way ANOVA revealed that those in the HUS class were significantly more likely to engage in unprotected anal and vaginal sex when compared to the LSR, and both LSR and MSR classes, respectively. Furthermore, those in the MSR class were also significantly more likely to engage in unprotected vaginal sex when compared to those in the LSR class. Conversely, those in the HUS class were significantly less likely to engage in sex for trade and oral sex, when compared to the MSR and LSR classes. Additionally, the MSR class was significantly more likely to engage in oral sex when compared to the LSR. For details regarding class difference, refer to Table 3. After deriving and defining the 3-class solution, I repeated Step

1 using a 3-class LTA solution. The test of measurement invariance yielded a model where the three sexual risk behavior classes were the same across the four time points.

3.1.1 Transitional probability and HIV/STI incident

Results from the three-class LTA yielded 81 possible latent statuses. The most popular status included nearly a third of the sample (29%; n =155), comprising a pattern where at Time 1 members were in the HUS class and then transitioned to and stayed in the MSR for Times 2 through 4. The second most popular status included 15.7% (n = 84) of the sample, comprising of a pattern of starting and staying in the LSR class across all time points. The third most popular status included 9.2% (n = 49) of the sample, comprising of a pattern where in individuals were in the HUS class at Times 1 and 2, and then transition to and stay in the MSR class for Times 3 and 4. The next most popular status included 8% (n = 43) of the sample, comprising of a pattern where in individuals were in the LSR class at Times 1 and 2, and then transition to and stay in the MSR class for Times 3 and 4. The next most popular status included 7.1% (n = 38) of the sample, comprising of a pattern where in individuals were in the HUS class at Time 1, LSR class at Time 2, and then transition to and stay in the MSR class for Times 3 and 4. The remaining 76 patterns comprised fewer than 5% of the sample, but provided insights in to unique shifts in sexual risk behavior overtime, further examined in AIM 2. The probability of transitioning between classes is reported in Table 4 and is visualized in Figure 7.

3.1.1.1 Time 1 to Time 2.

A majority (79.8%) of those that started in the LSR stayed in the LSR by Time 2. Half (52.7%) of those who started in the MSR class moved to the LSR by Time 2. Nearly half of the individuals who started in the HUS class and shifted to the MSR by Time 2 (49.8%). Post-hoc multinomial regression analyses revealed that Time 1 class membership significantly predicted

Time 2 class membership (χ^2(4, n = 535) = 248.684, Nagelkerke R^2 = .457, p ≤.001), but not HIV/STI incident (χ^2 (2, n = 535) = 1.136, p =.567). Specifically, membership in the LSR class at Time 2 was significantly lower for those in the MSR class (OR = .089, 95%CI[.033, .239]) or the HUS class (OR = .064, 95%CI[.032, .128]) when compared to those in the LSR class at Time 1. Conversely, membership in the MSR at Time 2 was significantly higher for those in the HUS class when compared to the LSR class at Time 1 (OR = 2.386, 95%CI[1.005, 5.664]).

3.1.1.2 Time 2 to Time 3.

Of those in LSR class at Time 2, 45.5% stayed in LSR class and 40.7% moved to the MRS class by Time 3. Similarly, 87.7% of those in the MRS class stayed in the MRS class by Time 3. Conversely, 69.2% of those in HUS at Time 2 moved to MRS by Time 3. Post-hoc multinomial regression analyses revealed that Time 2 class membership significantly predicted Time 3 class membership (χ^2(4, n = 535) = 160.108, Nagelkerke R^2 = .299, p ≤.001), but not HIV/STI incident (χ^2 (2, n = 535) = .137, p = .934). Specifically, membership in the LSR class at Time 3 was significantly lower for those in the MSR class (OR = .259, 95%CI[.091, .732]) or the HUS class (OR = .108, 95%CI[.040, .291]) when compared to those in the LSR class at Time 2. Conversely, membership in the MSR at Time 2 was significantly higher for those in the MSR class when compared to the LSR class at Time 2 (OR = 5.867, 95%CI[2.562, 13.436]).

3.1.1.3 Time 3 to Time 4.

Of those in the LSR class at 3, a majority (74.4%) remained in LSR class by Time 4. Similarly, 80% of those in MSR at Time 3 stayed in MSR by Time 4. And, nearly half (46.8%) of those in the HUS at Time 3 moved to the MSR by Time 4. Post-hoc multinomial regression analyses revealed that Time 3 class membership significantly predicted Time 4 class membership (χ^2(4, n = 535) =305.607, p ≤.001), and HIV/STI incident (χ^2 (2, n = 535) = 7.612 p = .022). This

model explained 54.3% (Nagelkerke R^2) of the total variance. Specifically, membership in the LSR class at Time 4 was significantly lower for those in the MSR class (OR = .089, 95%CI[.032, .249]) or the HUS class (OR = .034, 95%CI[.010, .112]) when compared to those in the LSR class at Time 3. Conversely, membership in the MSR at Time 4 was significantly higher for those in the MSR class when compared to the LSR class at Time 3 (OR = 7.150, 95%CI[2.466, 20.730]). Additionally, HIV/STI incident at Time 4 was significantly lower for those in the HUS class when compared to those in the LSR class at Time 3 (OR = .322, 95%CI[.114, .911]).

3.2 Aim 2

3.2.1 Latent growth curve model:

I observed incremental improvement in several model fit indices (BIC, AIC, Entropy, etc.) as the number of classes was increased from 1 to 4 (Table 5). Of note I found that the while there was an incremental improvement in fit indices from a one to two class model solution, a 3-class solution yielded an increase in BIC and no change in the sample size adjusted BIC. Further examination revealed a nonsignificant LMR-LRT p value when comparing it two- and a three-class model; suggesting that there was no significant improvement in model fit with the addition of a third-class.

3.2.1.1 Unconditional model.

The final relationship dependency analyses included responses from both male and female participants. This combined response was then used to model the change in dependencies over four time points to estimate the latent growth curve model. Final latent growth curve model yielded two unique trajectories: 1) Stable Dependencies (n = 915; 85.9%), and 2) Increase Dependencies (n = 149; 14.1%; Figure 8). Among those with Stable Dependencies there was a lower intercept (M = 38.506, SE = 0.842) and nonsignificant flat linear slope (M = -0.144, SE =

0.185, p = 0.435) over time. Among those in the Increase Dependencies trajectory, there was a higher intercept (M = 44.956, SE = 2.015), and was significant positive slope (M = 3.457, SE = 1.489, p = 0.020) overtime.

3.2.1.2 Conditional model.

A baseline covariate of treatment condition was included in the conditional model to adjust for possible effects of intervention group membership. I found a significant effect of treatment condition membership on trajectory membership at baseline. Specifically, membership in EBAN intervention was associated with a 2.66 times increased likelihood of membership in the Increase Dependencies trajectory (Est. = 0.977, S.E = 0.314, p = 0.002). The full conditional model retained the basic shape of trajectories as the unconditional model. There was a change in class prevalence with 1) Conditional Stable Dependencies (n = 869; 81.2%), and 2) Conditional Increase Dependencies (n = 196; 18.3%). In the conditional model, significant slope for the Increase Dependencies trajectory was no longer significant after controlling for treatment condition at baseline.

3.2.1.2 Distal outcome.

I tested whether prospective relationship dependencies trajectories predicted incident of HIV and STI Time 4, using a fully conditional model to control for baseline covariate of treatment condition membership. Results indicated no significant difference in likelihood of developing new HIV or STI diagnosis at Time 4 based on class membership.

To further characterize the trajectories, I conducted additional post-hoc repeated measures ANOVA on impact of STI diagnosis at each timepoint, to test for effects of time, class, and interactions between time and conditional class membership. There was significant quadratic effects of time on having any STI diagnoses [$F(1, 828) = 16.418$; $p < .001$; partial $\eta 2 = 0.019$],

such that there was a significant decrease in the number of STI diagnosis from Time 1 (M = .139, SE = .015) when compared to Time 2 (M = .065, SE = .012), 3 (M = .057, SE = .010), and 4 (M = .061, SE = .011). There was no significant main effect of conditional class membership (F(1, 828) =0.051; p =.537) or interaction between time and class (F(3, 826) = 1.144; p =.330) upon the diagnoses of STIs.

3.2.2 Parallel Process Latent Growth Model to test Relationship Dependencies as Mediator:

I assessed the mediational role of relationship dependencies between individual sexual risk behaviors status over time and HIV/STI incident.

3.2.2.1 Class at Time 1 and Transition between Time 1 to Time 2.

Class membership at Time 1 was significantly associated with change in relationship dependencies. Specifically, those in the High Unprotected Sex class had a significantly greater change in relationship dependencies (M = .5077) when compared to those in the Low Sexual Risk (M = .18608) and the Medium Sexual Risk (M = .09207) classes. There was a significant association between change in relationship dependencies and HIV/STI incident, such that with as relationship dependencies increase, there is a reduction in the likelihood of HIV/STI incident at Time 4 (b = -.6407, z(3) = -2.09, p = .0365, 95% CI [-1.2412, -.0402].

The relationship between Time 1 class membership and HIV/STI incident at Time 4 was fully mediated by relationship dependencies such that those in the Low Sexual Risk (n = 18, 9.4%; indirect effect = -.2061, SE = .1281, 95% CI[-.5396, -.0530]) and Medium Sexual Risk (n = 3, 10.3%; indirect effect = -.2664, SE = .1576, 95% CI [-.6632, -.0729] classes were significantly less likely to have an HIV/STI incident when compared to those in the High Unprotected Sex (n = 31; 9.8%) class at Time 1 (Figure 9).

In expanding this mediational model, I examined the impact on transition status between Time 1 and Time 2 on outcomes. Of note, I found that those who were in High Unprotected Sex class at Time 1 and Low Sexual Risk (M = .54255) at Time 2 or Medium Sexual Risk (M = .51180) at Time 2 or stayed in the High Unprotected Sex (M = .46423) at Time 2 had a significantly greater change in relationship dependencies when compared to those who stated in the Low Sexual Risk class from Time 1 to Time 2 (M = .19884). Additionally, there was a significant direct relationship between transition between classes and HIV/STI incident such that those who remained in the Low Sexual Risk class between Time 1 and Time 2 were significantly less likely to contract HIV/STI at Time 4, when compared to those that moved from the High Unprotected Sex class at Time 1 to Low Sexual Risk class at Time 2 (b = .9507, SE = .4395, z(9)= 2.1631, p = .0305, 95% CI [.0893, 1.8122]).

I found that the relationship between the transition between classes from Time 1 to Time 2 and HIV/STI incident at Time 4 was partially mediated by relationship dependencies. Specifically, those who stayed in the Low Sexual Risk class between Time 1 and Time 2 were significantly less likely to have an HIV/STI incident when compared to those that started in the High Unprotected Sex class at Time 1 and either stayed in High Unprotected Sex (indirect effect = -.1659, SE = .1253, 95% CI[-.4789, -.0275]) or moved to Medium Sexual Risk (indirect effect = -.1957, SE =.1301, 95% CI [-.5390, -.0547]) or Low Sexual Risk (indirect effect = -.2149, SE = .1427, 95% CI [-.5933, -.0470]) classes at Time 2 as a function of change in relationship dependencies (Figure 13).

3.2.2.2 Class at Time 2 and Transition between Time 2 to Time 3.

Class membership at Time 2 was significantly associated with change in relationship dependencies. Specifically, those in the Medium Sexual Risk class had a significantly greater

change in relationship dependencies (M = .47874) when compared to those in the Low Sexual Risk (M = .28264) class. The relationship between Time 2 class membership and HIV/STI incident at Time 4 was fully mediated by relationship dependencies. Specifically, those in the Low Sexual Risk class (11.2%) were significantly more likely to have an HIV/STI incident when compared to those in the Medium Sexual Risk (7.8%; indirect effect = -.1109, SE = .0942, 95% CI [-.3650, -.0128]) class as a function of change in relationship dependencies (Figure 11).

When examining the relationship between the transition between classes from Time 2 to Time 3 and HIV/STI incident at Time 4, there was a significant relationship between transition between classes and relationship dependencies. Specifically, all of those that transitioned to Medium Sexual Risk class by Time 3, regardless of class status at Time 2, had significantly greater change in relationship dependencies when compared to those who remained in the Low Sexual Risk class between Time 2 and Time 3.

When examining the relationship between the transition between classes from Time 2 to Time 3 and HIV/STI incident at Time 4, I found that this relationship was fully mediated by relationship dependencies. Specifically, as a function of change in relationship dependencies, those in who stayed in the Low Sexual Risk class between Time 2 and Time 3 were significantly more likely to have an HIV/STI incident when compared to those who transitioned to the Medium Sexual Risk class by Time 3, regardless of membership at class Time 2 (Figure 14).

3.2.2.3 Classes at Time 3 and Time 4, and Transition between Time 3 to Time 4.

Class membership at Time 3 was significantly associated with change in relationship dependencies and HIV/STI incident. Specifically, those in the Medium Sexual Risk class (M = .49033) had a significantly greater change in relationship dependencies when compared to those in the Low Sexual Risk class (M = .09245). Additionally, membership in High Unprotected Sex

class at Time 3 was associated with HIV/STI incident when compared to Low Sexual Risk (b = .9224, SE =.4424, z(3) = 2.0851, p = .0371, 95% CI [.0554, 1.7895]) and Medium Sexual Risk (b = 1.1737, SE =.4006, z(3) = 2.9295, p= .0034, 95% CI [.3884, 1.9589]) classes at Time 3. The relationship between Time 3 class membership and HIV/STI incident at Time 4 was partially mediated by relationship dependencies. Specifically, those in the Low Sexual Risk class were significantly more likely to have an HIV/STI incident when compared to the Medium Sexual Risk as a function of change in relationship dependencies (indirect effect = -.22, SE = .1165, 95% CI [-.6665, -.0214]) classes (Figure 12).

There was a significant relationship between the transition between classes from Time 3 to Time 4 and change in relationship dependencies as well as HIV/STI incident at Time 4. Specifically, those that stayed in the Medium Sexual Risk had a greater change in relationship dependencies when compared to those that stayed in the Low Sexual Risk class between Time 3 and Time 4. Additionally, those that moved from the High Unprotected Sex to Medium Sexual Risk were significantly more likely to have a HIV/STI incident when compared to those that remained in the Low Sexual Risk class between Time 3 and Time 4 (b = 1.2392, SE = .5190, z(9) = 2.3875, p = .0170, 95% CI [.2219, 2.2565]).

When examining the relationship between the transition between classes from Time 3 to Time 4 and HIV/STI incident at Time 4, I found that this relationship was partially mediated by relationship dependencies. Specifically, the change in relationship dependencies mediated the relationship between those who stayed in the Low Sexual Risk class between Time 3 and Time 4 (n = 13, 11.4%) such that they were more likely to have an HIV/STI incident when compared to those who stayed in the Medium Sexual Risk class (n = 20, 6.6%; indirect effect = -.2534, SE = .1879, 95% CI [-.7339, -.0420]) as well as those who moved from High Unprotected Sex to

Medium Sexual Risk class (n = 8, 27.%; indirect effect = -.1595, SE = .1461, 95% CI [-.5635, -.0088]) between these time points.

Class membership a Time 4 was significantly associated with change in relationship dependencies. Specifically, those in the Medium Sexual Risk class (M = .50239) had a significantly greater change in relationship dependencies when compared to those in the Low Sexual Risk (M = .08952) and High Unprotected Sex (M= .24197) classes. The relationship between Time 4 class membership and HIV/STI incident at Time 4 was fully mediated by relationship dependencies. Specifically, as a function of change in relationship dependencies, those in the Low Sexual Risk class (n = 19; 12.7%) were significantly more likely to have HIV/STI incidents when compared to the Medium Sexual Risk (n = 29, 8.3%; indirect effect = -.22, SE = .1635, 95% CI [-.6373, -.0240]) classes (Figure 15).

3.3 Aim 3

3.3.1 Moderated Mediation:

I examined the impact of social determinants of health as moderators of the relationship between transition status between each time point, relationship dependencies, and HIV/STI incident. Specifically, I sought to test if the mediational role of change in relationship dependencies was moderated by a) rates of reported HIV, AIDS, and notifiable STIs, b) rates of educational attainment, unemployment rates, housing characteristics, poverty, c) violent crime rates, number of individuals under community supervision and incarceration, d) number of individual receiving substance use disorder treatment, and e) policy indicators (i.e. laws regarding contraception).

3.3.2 Transition from Time 1 to Time 2:

Previously, I identified that the relationship between transition status and HIV/STI incident was partially mediated by change in relationship dependencies when comparing those who stayed in the Low Sexual Risk class to those who started in the High Unprotected Sex class at Time 1 and then stayed in the High Unprotected Sex class or moved to Low Sexual Risk or Medium Sexual Risk classes at Time 2 (Figure 13).

For the moderated mediation analysis with HIV density as a moderator, I found that there was a differential mediation based on different values of the moderator for the full model only; such that mediational role of relationship dependencies on transition between Low to Low classes compared to staying or moving from the High Unprotected Sex to any other classes, was only present for those residing in areas with a mild reduction (50 %tile) and increase (84 %tile) in HIV density over time. Of note, the negative indirect effect suggests that those who remained in the Low Sexual Risk group from Time 1 and Time 2 were at an increased risk for HIV/STI incident when compared to their counterparts who stayed in High Unprotected Sex or moved from High Unprotected Sex to Low Sexual Risk or Medium Sexual Risk classes, who resided in similar areas. Examination of results revealed that there was no significant moderation on individual paths (i.e. Latent transition status to relationship dependences and relationship dependences to HIV/STI incident), instead, the significant moderated mediation was only present when considering the cumulative impact of HIV density on the mediational relationship.

For the moderated mediation analysis with AIDS density as a moderator, I found that there was a differential mediation based on different values of the moderator for the full model; such that mediational role of relationship dependencies on transition between Low to Low classes compared to a) staying or moving from the High Unprotected Sex to any other classes,

was only present for those residing in areas with a large (16 %tile) and mild (50 %tile) reduction in AIDS density over time, and b) those who stayed in the Medium Sexual Risk class or moved from the Medium Sexual Risk to High Unprotected Sex class, was only present for those residing in areas with large (16 %tile) reduction in AIDS density over time. Of note, the negative indirect effect suggests that those who remained in the Low Sexual Risk group from Time 1 to Time 2 were at an increased risk for HIV/STI indecent when compared to their counterparts who stayed or moved from the High Unprotected Sex to any other classes, who resided in similar areas (a) . In contrast, the positive indirect effect suggests that those who remained in the Low Sexual Risk group from Time 1 to Time 2 were at a decreased risk for HIV/STI indecent when compared to their counterparts who stayed in Medium Sexual Risk or moved from Medium Sexual Risk to High Unprotected Sex classes, who resided in similar areas (b). Examination of results revealed that there was no significant moderation on individual paths (i.e. Latent transition status to relationship dependences and relationship dependences to HIV/STI incident), instead, the significant moderated mediation was only present when considering the cumulative impact of AIDS density on the mediational relationship.

For the moderated mediation analysis with Chancroid density as a moderator, I found that there was a differential mediation based on different values of the moderator; such that mediational role of relationship dependencies on transition between Low to Low classes compared to: a) staying in the High Unprotected Sex classes was present for those residing in areas with no change (50 %tile) or small (84 %tile) increase in chancroid rates, b) moving from High Unprotected Sex to Low Sexual Risk was present for those residing in areas with reduction (16 %tile) or no change (50 %tile) in chancroid rates, and c) those who stayed in the Medium Sexual Risk was present for those residing in areas with reduction (16 %tile) in chancroid rates.

Of note, the negative indirect effect suggests that those who remained in the Low Sexual Risk group from Time 1 to Time 2 were at an increased risk for HIV/STI indecent when compared to their counterparts who stayed in the High Unprotected Sex class or moved from the High Unprotected Sex to Low Sexual Risk class, who resided in similar areas (a,b). In contrast, the positive indirect effect suggests that those who remained in the Low Sexual Risk group from Time 1 to Time 2 were at a decreased risk for HIV/STI indecent when compared to their counterparts who stayed in the Medium Sexual Risk class, who resided in similar areas (c). Examination of results revealed that there was no significant moderation on individual paths (i.e. Latent transition status to relationship dependences and relationship dependences to HIV/STI incident), instead, the significant moderated mediation was only present when considering the cumulative impact of Chancroid density on the mediational relationship.

For the moderated mediation analysis with poverty level as a moderator, I found that there was a differential mediation based on different values of the moderator; such that mediational role of relationship dependencies on transition between Low to Low classes compared to: a) staying in High Unprotected Sex class or moving from High Unprotected Sex to Medium Sexual Risk class, was only present for those residing in areas with small increase (50 %tile) in poverty level over time, and b) moving from High Unprotected Sex to Low Sexual Risk class was only present for those residing in areas with reduction (16 %tile) or small increase (50 %tile) in poverty level over time. Of note, the negative indirect effect suggests that those who remained in the Low Sexual Risk group from Time 1 to Time 2 were at an increased risk for HIV/STI indecent when compared to their counterparts who stayed or moved from the High Unprotected Sex to any other class, who resided in similar areas (a,b). Examination of results revealed that there was no significant moderation on individual paths (i.e. Latent transition status

to relationship dependences and relationship dependences to HIV/STI incident), instead, the significant moderated mediation was only present when considering the cumulative impact of poverty level on the mediational relationship.

For the moderated mediation analysis with violent crime frequency as a moderator, I found that there was a differential mediation based on different values of the moderator; such that mediational role of relationship dependencies on transition between Low to Low classes compared to those who stayed in High Unprotected Sex class was only present for those residing in areas with large (16 %tile) and small (50 %tile) decreases in violent crime over time. Of note, the negative indirect effect suggests that those who remained in the Low Sexual Risk group from Time 1 to Time 2 were at an increased risk for HIV/STI indecent when compared to their counterparts who stayed or moved from the High Unprotected Sex to any other class, who resided in similar areas. Examination of results revealed that there was no significant moderation on individual paths (i.e. Latent transition status to relationship dependences and relationship dependences to HIV/STI incident), instead, the significant moderated mediation was only present when considering the cumulative impact of the violent crime frequency on the mediational relationship.

For the moderated mediation analysis with number of individuals under parole as a moderator, I found that there was a differential mediation based on different values of the moderator; such that mediational role of relationship dependencies on transition between Low to Low classes compared to those who moved from High Unprotected Sex to Low Sexual Risk or stayed in the High Unprotected Sex class was present for those residing in areas with a small decrease (50 %tile) and increase (84 %tile) in number of individuals under parole over time. Of note, the negative indirect effect suggests that those who remained in the Low Sexual Risk group

from Time 1 to Time 2 were at an increased risk for HIV/STI indecent when compared to their counterparts who stayed in the High Unprotected Sex or moved to Low Sexual Risk class, who resided in similar areas. Examination of results revealed that there was no significant moderation on individual paths (i.e. Latent transition status to relationship dependences and relationship dependences to HIV/STI incident), instead, the significant moderated mediation was only present when considering the cumulative impact of the number of individuals under parole on the mediational relationship.

For the moderated mediation analysis with number of inmates held in jail as a moderator, I found that there was a differential mediation based on different values of the moderator; such that mediational role of relationship dependencies on transition between Low to Low classes compared to: a) those who stayed in the Medium Sexual Risk class was only present for those residing in areas with a decrease (16 %tile) in number of inmates held in jail over time, b) those who moved from High Unprotected Sex to Low Sexual Risk or stayed in the High Unprotected Sex class was only present for those residing in areas with a small increase (50 %tile) in number of inmates held in jail over time, and c) those who moved from High Unprotected Sex to Medium Sexual Risk was present for those residing in areas with a decrease (16 %tile) and small increase (50 %tile) in number of inmates held in jail over time. Of note, the positive indirect effect suggests that those who remained in the Low Sexual Risk group from Time 1 to Time 2 were at a decreased risk for HIV/STI indecent when compared to their counterparts who stayed in the Medium Sexual Risk class (a). In contrast, the negative indirect effect suggests that those who remained in the Low Sexual Risk group from Time 1 to Time 2 were at an increased risk for HIV/STI indecent when compared to their counterparts who stayed or moved from the High Unprotected Sex to any other class, who resided in similar areas (b,c). Examination of results

revealed that there was no significant moderation on individual paths (i.e. Latent transition status to relationship dependences and relationship dependences to HIV/STI incident), instead, the significant moderated mediation was only present when considering the cumulative impact of the number of inmates held in jail on the mediational relationship.

For the moderated mediation analysis with substance use treatment utilization as a moderator, I found that there was a differential mediation based on different values of the moderator; such that mediational role of relationship dependencies on transition between Low to Low classes compared to: a) those who moved from High Unprotected Sex to Medium Sexual Risk or stayed in the High Unprotected Sex class was present for those residing in areas with large (16 %tile) and small (50 %tile) decrease in substance use treatment utilization over time, and b) those who moved from High Unprotected Sex to Low Sexual Risk classes was only present for those residing in areas with small (50 %tile) decreases in substance use treatment utilization over time. Of note, the negative indirect effect suggests that those who remained in the Low Sexual Risk group from Time 1 to Time 2 were at an increased risk for HIV/STI indecent when compared to their counterparts who stayed or moved from the High Unprotected Sex to any other class, who resided in similar areas (a,b). Examination of results revealed that there was no significant moderation on individual paths (i.e. Latent transition status to relationship dependences and relationship dependences to HIV/STI incident), instead, the significant moderated mediation was only present when considering the cumulative impact of substance use treatment utilization on the mediational relationship.

For the moderated mediation analysis with Chlamydia, Gonorrhea, Syphilis, rates of educational attainment, unemployment rates, housing characteristics, number of inmates in prison, and presence of contraceptive coverage laws as moderators, I found that there was a no

significant differential mediation present, based on different values of the moderator. Details regarding magnitude of significant indirect effects, see Table 6.

3.3.3 Transition from Time 2 to Time 3:

Previously, I identified that the relationship between transition status and HIV/STI incident was fully mediated by change in relationship dependencies when comparing those who stayed in the Low Sexual Risk class to those who transitioned to the Medium Sexual Risk class by Time 3, regardless of membership at class Time 2 (Figure 14).

For the moderated mediation analysis with HIV density as a moderator, I found that there was a differential mediation based on different values of the dichotomous moderator; such that mediational role of relationship dependencies on transition between Low to Low classes compared to those who moved from Medium Sexual Risk to High Unprotected Sex (IMM = .3982, SE = .5491, 95% Bootstrap CI [.0390, 1.9143]) was only present for those residing in areas with a decrease in HIV density over time. A positive Index of Moderated Mediation suggest that the indirect effect of transition status from Time 2 to Time 3 on HIV/STI incident through relationship dependencies is positively moderated by change in HIV density over time. Of note, the positive indirect effect suggests that those who remained in the Low Sexual Risk group from Time 2 and Time 3 were at an decreased risk for HIV/STI incident when compared to their counterparts who moved from Medium Sexual Risk to High Unprotected Sex class during the same time and resided in similar areas. Examination of results revealed that there was no significant moderation on individual paths (i.e. Latent transition status to relationship dependences and relationship dependences to HIV/STI incident), instead, the significant moderated mediation was only present when considering the cumulative impact of HIV density on the mediational relationship.

For the moderated mediation analysis with Syphilis density as a moderator, I found that there was a differential mediation based on different values of the dichotomous moderator; such that mediational role of relationship dependencies on transition between Low to Low classes compared to those a) who moved from Low Sexual Risk to Medium Sexual Risk (IMM = -.7787, SE = .6124, 95% Bootstrap CI [-1.9562, -.1976]), and b) who moved from High Unprotected Sex to Medium Sexual Risk (IMM = -.5332, SE = .5644, 95% Bootstrap CI [-1.3947, -.0595]), was only present for those residing in areas with a decrease in Syphilis density over time. A negative Index of Moderated Mediation suggest that the indirect effect of transition status from Time 2 to Time 3 on HIV/STI incident through relationship dependencies is a decreasing function of the change in Syphilis density over time. Of note, the negative indirect effect suggests that those who remained in the Low Sexual Risk group from Time 2 and Time 3 were at an increased risk for HIV/STI incident when compared to their counterparts who moved from Low Sexual Risk to Medium Sexual Risk or High Unprotected Sex to Medium Sexual Risk class during the same time and resided in similar areas. Examination of results revealed that there was no significant moderation on the relationship between latent transition status to relationship dependences. The association between relationship dependencies and HIV/STI incident was moderated by different levels of Syphilis density; such that, for those residing in areas with a decrease in Syphilis density (b = -1.3041, z(1) = -2.3385, p = .0194, 95% CI [-2.3972, -.2111]), as relationship dependencies increase, there was a reduced likelihood of HIV/STI incident at Time 4.

For the moderated mediation analysis with Chancroid density as a moderator, I found that there was a differential mediation based on different values of the moderator; such that mediational role of relationship dependencies on transition between Low to Low classes

compared to those who: a) moved from Low Sexual Risk to Mid Risk, b) stayed in the Medium Sexual Risk class, c) moved from Medium Sexual Risk to High risk, and d) moved from High Unprotected Sex to Mid Risk, was present for those residing in areas with a no change (50 %tile) or increase (85 %tile) in Chancroid rates. Of note, the negative indirect effect suggests that those who remained in the Low Sexual Risk group from Time 2 to Time 3 were at an increased risk for HIV/STI indecent when compared to their counterparts listed above, who resided in similar areas (a-d). Examination of results revealed that there was no significant moderation on individual paths (i.e. Latent transition status to relationship dependences and relationship dependences to HIV/STI incident), instead, the significant moderated mediation was only present when considering the cumulative impact of Chancroid density on the mediational relationship.

For the moderated mediation analysis with poverty level as a moderator, I found that there was a differential mediation based on different values of the moderator; such that mediational role of relationship dependencies on transition between Low to Low classes compared to those who: a) moved from Low Sexual Risk to Medium Sexual Risk class, b) stayed in the Medium Sexual Risk class, c) moved from High Unprotected Sex to Medium Sexual Risk class, was present for those residing in areas with relative decrease (16 %tile) and small increase (50 %tile) in poverty level over time, and d) moved from Medium Sexual Risk to High Unprotected Sex class was only present for those residing in areas with relative decrease (16 %tile) in poverty level over time. Of note, the negative indirect effect suggests that those who remained in the Low Sexual Risk group from Time 2 to Time 3 were at an increased risk for HIV/STI indecent when compared to their counterparts listed above, who resided in similar areas (a-d). Examination of results revealed that there was no significant moderation on the relationship between relationship dependences and HIV/STI incident. The association between

latent transition status and relationship dependencies was moderated by different levels of poverty; such that, for those residing in areas with a relative decrease (16 %tile) and small increase (50 %tile) in poverty level over time, those that started in either Low Sexual Risk or High Unprotected Sex and transitioned to Medium Sexual Risk class by Time 3, had significantly greater change in relationship dependencies when compared to those who remained in the Low Sexual Risk class between Time 2 and Time 3.

For the moderated mediation analysis with violent crime frequency as a moderator, I found that there was a differential mediation based on different values of the moderator; such that mediational role of relationship dependencies on transition between Low to Low classes compared to those who: a) moved from Low Sexual Risk to Mid Risk, b) stayed in Medium Sexual Risk class, c) moved from High Unprotected Sex to Medium Sexual Risk class, was present for those residing in areas with large (16 %tile) and small (50 %tile) in violent crime frequency over time. Of note, the negative indirect effect suggests that those who remained in the Low Sexual Risk group from Time 2 to Time 3 were at an increased risk for HIV/STI indecent when compared to their counterparts listed above, who resided in similar areas (a-c). Examination of results revealed that there was no significant moderation on individual paths (i.e. Latent transition status to relationship dependences and relationship dependences to HIV/STI incident), instead, the significant moderated mediation was only present when considering the cumulative impact of violent crime frequency on the mediational relationship.

For the moderated mediation analysis with number of individuals under parole as a moderator, I found that there was a differential mediation based on different values of the moderator; such that mediational role of relationship dependencies on transition between Low to Low classes compared to those who moved from the High Unprotected Sex to Medium Sexual

Risk class was present for those residing in areas with a small decrease (50 %tile) and increase (84 %tile) in number of individuals under parole over time. Of note, the negative indirect effect suggests that those who remained in the Low Sexual Risk group from Time 2 to Time 3 were at an increased risk for HIV/STI indecent when compared to their counterparts who moved from High Unprotected Sex to Medium Sexual Risk class while residing in similar areas. Examination of results revealed that there was no significant moderation on the relationship between latent transition status to relationship dependences. The association between relationship dependencies and HIV/STI incident was moderated by different levels of the number of individuals under parole; such that, for those residing in areas with an small decrease (50 %tile; b = -.7325, z(1) = -2.1292, p = .0332, 95% CI [-1.4067, -.0582]) and increase (84 %tile; b = -.8913, z(1) = -2.3053, p = .0211, 95% CI [-1.6491, -.1335]) in the number of individuals under parole, as relationship dependencies increase, there was a reduced likelihood of HIV/STI incident at Time 4.

For the moderated mediation analysis with number of inmates held in jail as a moderator, I found that there was a differential mediation based on different values of the moderator; such that mediational role of relationship dependencies on transition between Low to Low classes compared to those who: a) moved from Low Sexual Risk to Medium Sexual Risk class, b) stayed in Medium Sexual Risk class, c) moved from Medium Sexual Risk to High Unprotected Sex class, and d) moved from High Unprotected Sex to Medium Sexual Risk class, was only present for those residing in areas with a small increase (50 %tile) in number of inmates held in jail over time. Of note, the negative indirect effect suggests that those who remained in the Low Sexual Risk group from Time 2 to Time 3 were at an increased risk for HIV/STI indecent when compared to their counterparts listed above, who resided in similar areas (a-d). Examination of results revealed that there was no significant moderation on individual paths (i.e. Latent

transition status to relationship dependences and relationship dependences to HIV/STI incident), instead, the significant moderated mediation was only present when considering the cumulative impact of the number of inmates held in jail on the mediational relationship.

For the moderated mediation analysis with number of inmates held in prison as a moderator, I found that there was a differential mediation based on different values of the moderator; such that mediational role of relationship dependencies on transition between Low to Low classes compared to those who: a) moved from Low Sexual Risk to Medium Sexual Risk class, b) stayed in Medium Sexual Risk class, and c) moved from High Unprotected Sex to Medium Sexual Risk class, was present for those residing in areas with a small decrease (50 %tile) in number of inmates held in prison over time. Additionally, when compared to those who stayed in Medium Sexual Risk class, there was an additional moderation effect for those residing in areas with an increase (85 %tile) in number of inmates held in prison over time. Of note, the negative indirect effect suggests that those who remained in the Low Sexual Risk group from Time 2 to Time 3 were at an increased risk for HIV/STI indecent when compared to their counterparts listed above, who resided in similar areas (a-d). Examination of results revealed that there was no significant moderation on individual paths (i.e. Latent transition status to relationship dependences and relationship dependences to HIV/STI incident), instead, the significant moderated mediation was only present when considering the cumulative impact of the number of inmates held in prison on the mediational relationship.

For the moderated mediation analysis with substance use treatment utilization as a moderator, I found that there was a differential mediation based on different values of the moderator; such that mediational role of relationship dependencies on transition between Low to Low classes compared to those who: a) moved from Low Sexual Risk to Medium Sexual Risk

class, b) stayed in Medium Sexual Risk class, c) moved from High Unprotected Sex to Medium Sexual Risk class, was present for those residing in areas with large (16 %tile) and small (50 %tile) decrease in substance use treatment utilization over time. Of note, the negative indirect effect suggests that those who remained in the Low Sexual Risk group from Time 2 to Time 3 were at an increased risk for HIV/STI indecent when compared to their counterparts listed above, who resided in similar areas (a-c). Examination of results revealed that there was no significant moderation on individual paths (i.e. Latent transition status to relationship dependences and relationship dependences to HIV/STI incident), instead, the significant moderated mediation was only present when considering the cumulative impact of substance use treatment utilization on the mediational relationship.

For the moderated mediation analysis with AIDS, Chlamydia and Gonorrhea density, rates of educational attainment, unemployment rates, housing characteristics, and presence of contraceptive coverage laws as moderators, I found that there was a no significant differential mediation based on different values of the moderator. Details regarding magnitude of significant indirect effects, see Table 7.

3.3.4 Transition from Time 3 to Time 4:

Previously, I identified that the relationship between transition status and HIV/STI incident was partially mediated by change in relationship dependencies when comparing those who stayed in the Low Sexual Risk class to those who stayed in the Medium Sexual Risk and those who moved from High Unprotected Sex to Medium Sexual Risk class between Time 3 and Time 4 (Figure 15).

For the moderated mediation analysis with AIDS density as a moderator, I found that there was a differential mediation based on different values of the moderator; such that

mediational role of relationship dependencies on transition between Low to Low classes compared to those who stayed in the Medium Sexual Risk class was present for those residing in areas with a large (16 %tile) and mild (50 %tile) reduction in AIDS density over time. Of note, the negative indirect effect suggests that those who remained in the Low Sexual Risk group from Time 3 to Time 4 were at an increased risk for HIV/STI indecent when compared to their counterparts who stayed in the Medium Sexual Risk class while residing in similar areas. Examination of results revealed that there was no significant moderation on the relationship between relationship dependences and HIV/STI incident. The association between latent transition status and relationship dependencies was moderated by different levels of AIDS density; such that, for those residing in areas with a relative decrease (16 %tile) in AIDS density over time, those that started in Low Sexual Risk class and transitioned to the High Unprotected Sex class by Time 3, had significantly greater change in relationship dependencies when compared to those who remained in the Low Sexual Risk class between Time 3 and Time 4.

For the moderated mediation analysis with Syphilis density as a moderator, I found that there was a differential mediation based on different values of the dichotomous moderator; such that mediational role of relationship dependencies on transition between Low to Low classes compared to those who: a) stayed in the Medium Sexual Risk class (IMM = -.7968, SE = .8090, 95% Bootstrap CI [-1.6852, -.0898]), b) moved from High Unprotected Sex to Medium Sexual Risk class (IMM = -.5247, SE = .4260, 95% Bootstrap CI [-1.6085, -.0704]), was only present for those residing in areas with a decrease in Syphilis density over time. A negative Index of Moderated Mediation suggest that the indirect effect of transition status from Time 3 to Time 4 on HIV/STI incident through relationship dependencies is a decreasing function of the change in Syphilis density over time. Of note, the negative indirect effect suggests that those who remained

in the Low Sexual Risk group from Time 3 and Time 4 were at an increased risk for HIV/STI incident when compared to their counterparts listed above and resided in similar areas. Examination of results revealed that there was no significant moderation on the relationship between latent transition status to relationship dependences. The association between relationship dependencies and HIV/STI incident was moderated by different levels of Syphilis density; such that, for those residing in areas with a decrease in Syphilis density ($b = -1.3142$, $z(1) = -2.3736$, $p = .0176$, 95% CI [-2.3994, -.2290]), as relationship dependencies increase, there was a reduced likelihood of HIV/STI incident at Time 4.

For the moderated mediation analysis with Chancroid density as a moderator, I found that there was a differential mediation based on different values of the moderator; such that mediational role of relationship dependencies on transition between Low to Low classes compared to those who: a) stayed in the Medium Sexual Risk class, and b) moved from High Unprotected Sex to Medium Sexual Risk class, was present for those residing in areas with a no change (50 %tile) or increase (85 %tile) in Chancroid rates. Of note, the negative indirect effect suggests that those who remained in the Low Sexual Risk group from Time 3 to Time 4 were at an increased risk for HIV/STI indecent when compared to their counterparts listed above, who resided in similar areas. Examination of results revealed that there was no significant moderation on individual paths (i.e. Latent transition status to relationship dependences and relationship dependences to HIV/STI incident), instead, the significant moderated mediation was only present when considering the cumulative impact of Chancroid density on the mediational relationship.

For the moderated mediation analysis with poverty level as a moderator, I found that there was a differential mediation based on different values of the moderator; such that mediational role of relationship dependencies on transition between Low to Low classes

compared to those who: a) stayed in Medium Sexual Risk class, and b) moved from High Unprotected Sex to Medium Sexual Risk Class, was present for those residing in areas with small increase (50 %tile) in poverty level over time. Additionally, when compared to those who stayed in the Medium Sexual Risk class, there was an additional moderation effect for those residing in areas with a decrease (16 %tile) in poverty levels over time. Of note, the negative indirect effect suggests that those who remained in the Low Sexual Risk group from Time 3 to Time 4 were at an increased risk for HIV/STI indecent when compared to their counterparts listed above, who resided in similar areas. Examination of results revealed that there was no significant moderation on the relationship between relationship dependences and HIV/STI incident. The association between latent transition status and relationship dependencies was moderated by different levels of poverty; such that, for those residing in areas with a relative large increase (84 %tile) in poverty levels over time, those that started in Low Sexual Risk class and transitioned to the High Unprotected Sex class by Time 3, had significantly greater change in relationship dependencies when compared to those who remained in the Low Sexual Risk class between Time 3 and Time 4.

For the moderated mediation analysis with violent crime frequency as a moderator, I found that there was a no significant mediation based on different values of the dichotomous moderator. Examination of results revealed that there was no significant moderation on the relationship between relationship dependences and HIV/STI incident. The association between latent transition status and relationship dependencies was moderated by different levels of violent crime; such that, for those residing in areas with an increase in violent crime frequency over time, those who started and stayed in the Medium Sexual Risk class between Time 3 and Time 4,

had significantly greater change in relationship dependencies when compared to those who remained in the Low Sexual Risk class between Time 3 and Time 4.

For the moderated mediation analysis with number of inmates held in jail as a moderator, I found that there was a differential mediation based on different values of the dichotomous moderator; such that mediational role of relationship dependencies on transition between Low to Low classes compared to those who moved from Low Sexual Risk to High Unprotected Sex class (IMM = 1.3931, SE = 1.0461, 95% Bootstrap CI [.3848, 4.5073]), was only present for those residing in areas with an increase in number of inmates held in jail over time. A positive IMM suggest that the indirect effect of transition status from Time 3 to Time 4 on HIV/STI incident through relationship dependencies is positively moderated by change in number of inmates held in jail, when comparing those who stayed in the Low Sexual Risk class to those who moved from Low Sexual Risk to High Unprotected Sex class. Specifically, for those residing in areas with an increase in number of inmates in jail, there is a positive indirect effect, suggesting that those who remained in the Low Sexual Risk group from Time 3 and Time 4 were at an decreased risk for HIV/STI incident when compared to those moved from Low Sexual Risk to High Unprotected Sex class, while residing in similar areas. Examination of results revealed that there was no significant moderation on the relationship between relationship dependences and HIV/STI incident. The association between latent transition status and relationship dependencies was moderated by different levels of number of inmates held in jail; such that, for those residing in areas with an increase in number of inmates held in jail over time, those that started in Low Sexual Risk class and transitioned to the High Unprotected Sex class by Time 3, had significantly reduction in relationship dependencies when compared to those who remained in the Low Sexual Risk class between Time 3 and Time 4.

For the moderated mediation analysis with number of inmates held in prison as a moderator, I found that there was a differential mediation based on different values of the moderator; such that mediational role of relationship dependencies on transition between Low to Low classes compared to those who: a) stayed in the Medium Sexual Risk class, and b) moved from High Unprotected Sex to Medium Sexual Risk class, was present for those residing in areas with a small decrease (50 %tile) in number of inmates held in prison over time. Of note, the negative indirect effect suggests that those who remained in the Low Sexual Risk group from Time 3 to Time 4 were at an increased risk for HIV/STI indecent when compared to their counterparts listed above, who resided in similar areas. Examination of results revealed that there was no significant moderation on individual paths (i.e. Latent transition status to relationship dependences and relationship dependences to HIV/STI incident), instead, the significant moderated mediation was only present when considering the cumulative impact of number of inmates held in prison on the mediational relationship.

For the moderated mediation analysis with presence of contraceptive coverage laws as a moderator, I found that there was a differential mediation based on different values of the dichotomous moderator; such that mediational role of relationship dependencies on transition between Low to Low classes compared to those who moved from Low Sexual Risk to High Unprotected Sex class (IMM = -.2463, SE = .2573, 95% Bootstrap CI [-.9805, -.0278]) was Index of Moderated Mediation suggest that the indirect effect of transition status from Time 3 to Time 4 on HIV/STI incident through relationship dependencies is a decreasing function of the change in areas with contraceptive coverage laws. Of note, the negative indirect effect suggests that those who remained in the Low Sexual Risk group from Time 3 and Time 4 were at an increased risk for HIV/STI incident when compared to their counterparts who moved from Low

Sexual Risk to High Unprotected Sex class while residing in similar areas. Examination of results revealed that there was no significant moderation on the relationship between relationship dependences and HIV/STI incident. The association between latent transition status and relationship dependencies was moderated by different levels of contraceptive coverage laws; such that, for those residing in areas with contraceptive coverage laws, those who started and stayed in the Medium Sexual Risk class between Time 3 and Time 4, had significantly greater change in relationship dependencies when compared to those who remained in the Low Sexual Risk class between Time 3 and Time 4.

For the moderated mediation analysis with HIV, Chlamydia, and Gonorrhea density, rates of educational attainment, unemployment rates, housing characteristics, substance use treatment utilization, and number of individuals under parole as moderators, I found that there was a no significant differential mediation based on different values of the moderator. Details regarding magnitude of significant indirect effects, see Table 8.

Chapter 4: Discussion

Findings from this dissertation revealed unique patterns and pathways via which African American women in serodiscordant relationships contracted HIV/STI. I discovered three patterns in sexual risk behaviors, with a majority of women engaging in high levels of unprotected vaginal and anal sex (HUS; n =315) at the beginning of the study. Of note, those women who engaged in high levels of unprotected vaginal and anal sex at Time 3 (i.e. Six months post-intervention) were significantly more likely to contract HIV/STI when compared to their counterparts in the Low and Medium Sexual Risk Classes. These findings are consistent with the large body of literature suggesting that increased engagement in unprotected anal and/or vaginal sex increased risk for HIV/STI incidents (Powers, Poole et al. 2008, Bowleg, Teti et al. 2011, Patel, Borkowf et al. 2014). High-Medium-Low risk behavior typologies have been found in a number of studies (e.g.El-Bassel, Davis et al. 2019) and this dissertation provides a rubric by which to incorporate multiple sources and levels of data into this assessment. By examining the predictive validity of these typologies, these findings help clarify that when examined non-contextually, engaging in high-risk behaviors confers risk of HIV/STI infections. The types of behaviors included in the derivation of the latent classes can inform how well these typologies predict negative health outcomes. For example, in a LCA of drug use among individuals under community supervision in New York City, we found that the underlying typology of drug use was associated with higher rates of criminal justice involvement as well as increased risky behavior with sexual partners (El-Bassel, Davis et al. 2019).

Results from the Latent Transition Analyses yielded 81 possible paths along which the women's sexual risk behavior changes over the course of the study. Of note, when compared to women who did engage in minimal sexual risk behaviors from Time 1 to Time 2 (i.e. Low

Sexual Risk Class), those women who started the study engaging in high levels of unprotected sex and were engaging in minimal levels of sexual risk behaviors by Time 2 were at significantly higher risk of contracting HIV/STI by the end of the study. Similarly, when compared to women who engaged in minimal sexual risk behaviors from Time 3 to Time 4 (i.e. Low Sexual Risk Class), those women who moved from engaging in high levels of unprotected sex at Time 3 to moderate levels of sexual risk behaviors by the end of the study were at a significantly higher risk for contracting HIV/STI. The analysis from the dissertation leaves the possibility for different possible explanations for these effects, ranging from study specific intervention effects, impact of HIV/STI testing, or knowledge of HIV/STI status. I was unable to assess if the time of HIV/STI incident over the course of the study influenced sexual risk behaviors, as HIV was only assessed at the beginning and end of the study; there is a possibility that STI incident, tested at each time point, could have influenced their behavior. For example, if an individual was engaging in high levels of unprotected sex at Time 2 and learned they had contracted an STI, they may engage in fewer sexual risk behaviors by Time 3 as a function of their knowledge of their STI diagnoses. van Wees, Drissen et al. (2020) reported that STI testing and consultation following positive test results was associated with a reduction in the number of sexual partners, increase condom use, and STI testing; while individuals who were not treated after a positive test result engaged in decreased condom use. This may in part be explained by the impact that learning one's serostatus has on sexual risk behaviors. In a systematic review of 14 studies examining shifts in sexual behavior among HIV-negative partners upon learning their serostatus, researchers found that there was a significant increase in the proportion of sex acts involving condom use used after HIV testing. Ramachandran, Mishra et al. (2016) also found that serodiscordant couples were more likely to use condoms after HIV testing, even if they did so

inconsistently, and were more likely to have sex with more partners concurrently. de Melo, Sprinz et al. (2019) reported that prior presence of STI was a predictor of seroconversion among serodiscordant heterosexual couples. These findings partially align with the findings from this study, suggesting that knowledge of HIV/STI status, STI testing at each assessment point, or presence of STIs, may possibly lead to behavioral change among HIV-negative individuals in serodiscordant relationships, with reduction in unprotected sexual acts within the relationship, but increase sex outside of the relationship; thus, possibly explain the increased incident of HIV/STI in such groups. My findings also underscore the utility of assessing and incorporating longitudinal latent patterns of risk behaviors as an important metric in intervention sciences. Specifically, identification of at-risk individuals and then modeling their latent status can provide researchers with a metric to assess for changes in underlying latent phenomena over the course of an intervention. For example, Mackesy-Amiti, Finnegan et al. (2013) used LTA to identify if intervention effects were consistent or different across various patterns of injection drug use risk behaviors. This method allowed these researchers to identify that their intervention was only effective among those in the high-risk class, while failing to elicit change among those Low, Moderate, and unique risk behavior classes (Mackesy-Amiti, Finnegan et al. 2013).

Inclusion of relationship dynamics in our understanding of how individual sexual risk behaviors led to HIV/STI incidents revealed that the quality of the relationship has a significant impact on this process. Specifically, reduction in frequency and increased difficulties in discussing sexual behaviors within a relationship as well as unfavorable views regarding how often others engage safe sex behaviors, was associated with an increased risk of HIV/STI incident. Furthermore, I found that with the inclusion of these relationship dynamics as a possible mediator had an inverse effect on the relationship between individual behavior and

HIV/STI incident; such that, those who continually engaged in low levels of sexual risk behaviors between time points were at the greatest risk for contracting HIV/STI by the end of the study. Specifically, I found that among couples who had poor communication about sex, even low levels of sexual risk behaviors put them at a greater risk for HIV/STI than their counterparts engaging in higher levels of unprotected sex, while effectively communicating about sex. This finding highlights the key mediating role that healthy relationship dynamics play in reducing the likelihood of contracting HIV/STI among African American women in serodiscordant relationships. These results also replicate prior secondary analyses of parent study data, finding that self-efficacy in negotiating safe sex in the relationship mediated the effect of the interventions in reducing sexual risk behaviors (El-Bassel, Jemmott et al. 2016). In a systematic review of 40 studies examining the role of social support and sexual and drug risk behaviors, Qiao, Li et al. (2014) found that having social support was associated with fewer risky behaviors, while a high degree of relationship dependency lead to increased sexual and drug risk behaviors. Having known the importance of these findings, there has been a growing use of couple-based interventions aimed at improving relationship dynamics. In a meta-analysis of 15 studies examining the impact of couple-based interventions compared to individual-based interventions, researchers found that the former was more effective in increasing protective sex, testing, and treatment for HIV (Crepaz, Tungol-Ashmon et al. 2015). A systematic review of 28 studies examining risk reduction interventions among heterosexual African American women found that these interventions were effective in reducing unprotected sex, increase one's ability to communicate regarding sexual practices and improved self-efficacy (Sophus and Mitchell 2021). These reviews and findings from this dissertation, highlight the important and potentially protective role that relationship dynamics and context can play in reducing risk for HIV/STI.

These findings also provide guidance for clinicians working with women who are HIV+ or in a serodiscordant relationship, by lending credence to the use of interpersonal assessments of HIV/STI risk. This can take the form of: 1) providing increased assessment of relationship dynamics and dependencies during the intake process, 2) offering effective communication strategies (e.g. DBT interpersonal effectiveness skills), 3) providing access to PrEP and other prophylaxis to increase empowerment and reduce dependencies. Several qualitative and quantitative studies have identified socio-cultural factors such as religiosity and social support as possible facilitators of engagement in prevention and treatment efforts. For example, Wingood, Robinson et al. (2013) implemented a two-arm comparative effectiveness trial of two faith-based HIV interventions (i.e. Sisters Informing Sisters about Topics on AIDS (SISTA) and P4) administered by African American women in a church setting for African American women. Specifically, P4 sought to increase religious social support to improve HIV prevention by connecting black women with social resources available through connections via their religious community by increasing ethnic and gender pride as well as enhancing coping skills. Findings from this intervention study found that both the initial (SISTA) and adapted faith-based (P4) HIV preventions intervention resulted in consistent condom use in the past 90 days (Wingood, Robinson et al. 2013).

Without the inclusion of social determinants as moderators, the consensus across the results was that those couples who did not communicate well about sex were at a higher risk of contracting HIV/STI, even when engaging in low levels of sexual risk behaviors. With the inclusion of social determinants as moderators, in some instances this effect was reversed and others where new at-risk groups emerged. This suggested that as fewer individuals in a community were infected with HIV, AIDS, or STIs, or fewer individuals were incarcerated in

jails, or if individuals resided in states with laws in favor of contraceptive coverage at different points in the study, a new group of individuals (i.e. those engaging in moderate levels of sexual risk behaviors) were at a greater risk for contracting HIV/STI. This would suggest that if structural level interventions such as increased funding for HIV/STI treatment or implementation of alternative to incarceration programs were to be deployed, policy makers should also plan to allocate additional resources to help those that will be newly at risk who would not have previously been eligible or availed of HIV/STI prevention and care services. Furthermore, these findings also suggest that efforts in areas with pre-existing resources to address social determinants should be focused on micro-epidemics among those engaging in moderate levels of risk behaviors.

Additionally, there were conditions under which previously at-risk groups were no longer at risk for incidents of HIV/STI. Specifically, those who continually engaged in low levels of sexual risk behaviors between time points were no longer at a greater risk for contracting HIV/STI when compared to their counterparts who engaged in high levels of unprotected sex and/or moderate levels of sexual risk behaviors. This suggested that as fewer individuals in a community were afflicted with STIs, or fewer individuals were living in poverty or incarcerated in jails, or as more individuals sought treatment for substance use disorders, at different points in the study, previously at-risk groups (i.e. those who engaged in low levels of sexual risk behaviors) were no longer at a greater risk for contracting HIV/STI. This suggests that a possible target for greatest impact via a structural intervention would be to focus on increased access to STI and substance use treatments as well as introducing policies that reduce income inequality and provide alternatives to incarceration.

These complex and even at times contradictory findings highlights the different ways in which social determinants can differentially impact individual's behaviors, their relationships, and HIV/STI status, over time. One trend suggests that, as there is a reduction in socioeconomic disparities, a reduction in the concentration infectious diseases, reduced criminal justice involvement, increased access to prevention services, and increased use of treatment services, the relative risk for previously at-risk individuals to contract HIV/STI is no longer present, regardless of their individual behaviors and relationship dynamics. Another trend suggests that as there is a reduction in the concentration infectious diseases, reduced criminal justice involvement and increased access to prevention services, new groups of individuals at greater risk for HIV/STI infection emerge. The impact of these social determinants is not limited to individuals, couples, and communities, but can also impact the efficacy of interventions. For example, a meta-analysis of 20 RCTs examining the effectiveness of peer navigator interventions for people living with HIV found an improvement in adherence to anti-retroviral therapy, viral suppression, and retention in care (Berg, Page et al. 2021), a review of reasons for failure to connect to services despite peer navigation identified structural barriers such as affordable housing and poverty (e.g. Cabral, Davis-Plourde et al. 2018).

While some of these findings are supported in part by our current understanding of the interplay between social determinants and HIV/STI, there is a need to translate and match these indicators to actionable interventions that can aid in the prevention of HIV (Kurth, Celum et al. 2011). Therefore, depending on the number of resources available for prevention efforts, there are different targets for interventions at the different levels: 1) Individuals engaging in unprotected sex, or 2) Couples in relationships with poor communication regarding sexual

practices, or 3) Communities with greater burden of STI, high rates of incarceration, poverty, and substance abuse.

Prior studies seeking to organize and define structural interventions, which address social determinants of HIV among others, have suggested possible taxonomies to better categorize interventions seeking to reduce HIV via changes in the environmental disparities. Tsai (2012) suggested two axes a) implementation intensity, from one-time to ongoing and b) user dependence, from structural to agentic. This multiaxial system provides opportunities to create and target different levels of change via structural interventions. In a comprehensive review and synthesis of 213 structural-level HIV prevention interventions, (Sipe, Barham et al. 2017) developed a taxonomy that included interventions targeting: a) access to health care, b) policy/procedures, c) mass media communication, d) physical structures and built environment, e) capacity-building among providers, f) community mobilization of stakeholders, and g) survival, acceptance via social determinants of health. Methods developed from this dissertation provide tools that can be used to measure and model changes across these different taxonomies. The flexibility and adaptability offered by latent variable modeling can allow researchers to effectively assess relevant targets for change across multi-levels of intervention and provide metrics to inform efforts on how to modulate intervention effects over time. Additionally, these methods can help test more detailed and complex relationships between endemic conditions by modeling cooccurring, mutually informing social phenomena that lead to increase burden of illness among vulnerable populations (Singer, Erickson et al. 2006, Koblin, Grant et al. 2015, Sullivan, Messer et al. 2015, Nehl, Klein et al. 2016, Godley and Adimora 2020). (Dale and Safren 2018, Harrison and Li 2018)

4.1 Strengths

A key strength of this dissertation was the ability to model complex relationship between theoretically relevant factors in a large sample, while maintain interpretability of the findings. Prior efforts to gain such insights were limited to idiographic approaches, relying on methods such as ethnographies or case studies, each providing greater details about these processes, but failing to generalize. Instead, this dissertation was able to provide idiographic findings on a nomothetic scale. Additionally, prior efforts to study syndemic processes have be limited by observational, retrospective, and cross-sectional designs as well as the lack of modeling of multilevel processes. This dissertation overcomes these limitations by using multiple levels of prospective indicators, from biological assays for HIV/STI, self-report of individual risk behaviors, partner-reported relationship dynamics, to community-level measures of social determinants, at a national scale. I additionally provide a robust method to study complicated processes without oversimplifying the indicators or processes. By using latent variable models, I was able to retain the information derived from numerous observable indicators and the relationship between them, while synthesizing them into parsimonious meaningful latent constructs and processes. The applications of such methods in improving prevention and intervention sciences are discussed below.

4.2 Limitations

Despite these strengths, there are a number of limitations to this study. Firstly, despite the relevance of the research questions, the study data collected was nearly two decades ago. There have been substantial changes to HIV prevention efforts, from the update to the Ryan White act in 2009, passage of affordable care act (i.e. Obamacare) in 2010, to the advent and wide availability of pre-exposure prophylaxis (PrEP) in 2012, and the introduction of the 90-90-90

strategy to end the HIV pandemic (Johnson and Heisler 2015, Desai, Field et al. 2017, Sullivan, Rosen et al. 2020). Each of these changes to policies and prevention tools have had substantial role in reducing the impact of interpersonal relationship dynamics by democratizing access to pre-exposure prophylaxis. Furthermore, the increased access to health care services can have substantial effect on the underlying process perpetuating multiple endemic conditions (e.g. lack of availability or access to prevention and early treatment services). Secondly, the lack of observational data makes it difficult to parse out if the changes in outcomes are independent of treatment effects. While I was able to statistically account for membership in treatment conditions, the study data was collected as a part of a cluster-RCT attempting to reduce sexual risk behaviors, and thus introduces intervention specific effects that would have been absent from an observational study. Additionally, current analyses do not account for racial/ethnic differences within and across couples which may reveal possible differential relationship between constructs in this study. Furthermore, due to the limitations in assessment, I was only able to predict HIV/STI incidents at the last time point of the study. This makes it difficult to parse out when the incident occurred over the course of the study and how it might have impacted the participants behaviors and relationship. Lastly, the measures for social determinants were collected at the city- or state-level, failing to provide greater granularity in my ability to inferences at a zip code or census-tract level.

4.3 Future Directions

The utility of this modeling approach should be tested with updated data accounting for limitations listed above. Specifically, these analytic methods could be used to model localized micro-epidemics of HIV given the level of granularity now available in geospatial data. Considering the advances and sophistication now available in GIS analyses, future efforts should

aim to collect and derive index scores for various social determinates at the census-tract level and leverage analytic advances to study hotspots and model spatial time series processes. Current efforts by the Localized HIV Modeling Study Group have shown the utility of using such approaches to identify regionally specific implementation strategies for evidence-based interventions (Nosyk, Zang et al. 2020). With the proliferation of artificial intelligence and machine learning approaches, there is a growing movement to use these methods to address HIV prevention efforts (Marcus, Sewell et al. 2020, Xiang, Du et al. 2021). With the methods developed in the dissertation providing the ability to model complex relationships between theoretically relevant factors, the next step would be to incorporate these findings into machine learning approaches such as deep neural networks (DNN). These methods (e.g. DNN) are an extension of latent variable modeling, which incorporate a complex and iterative feedback loops to 'learn' how to improve model fit using high-dimensional data. Specifically, the models derived in the dissertation can be used to specify, weight, and build theoretically meaningful "hidden-layers" withing the neural network approaches, which are statistically akin to the latent models used in this study. The added benefit of a DNN approach would be its ability to incorporate and adapt to new streams of data, as it became available, improving the ability to predict HIV/STI incidents with greater accuracy, specificity, and sensitivity on a larger scale. An additional future direction of this work would be to find opportunities to test and validate these findings in observational and unstructured data. Approaches leveraging the use of Electronic Medical Records (EMR) and methods such as Natural Language Processing, allow us to take findings from this dissertation and apply them directly to clinical decision support tools. This can have impacts in prevention and treatment along the HIV care continuum, by providing approaches to identify individuals at risk (e.g. latent classes), model the course of change in their

risk as a function of treatments provided (e.g. latent status), and even identify targets to improve retention in care based on risk typologies and transition between these typologies over the course of their engagement in HIV care based on geospatial factors (e.g. Ridgway, Lee et al. 2021). Examples of such efforts can already be seen the largest integrated national healthcare delivery system in the United States, The Veterans Health Administration (e.g. Justice, Modur et al. 2013, Chartier, Gylys-Cowell et al. 2018, Hasin, Fink et al. 2022).

Conclusion

Findings from this dissertation revealed unique patterns and pathways via which African American females in serodiscordant relationships contracted HIV/STI. These results highlight the importance of modeling complex relationship, finding that naïve models which do not incorporate the powerful role of relationship dynamics, would have failed to identify women at highest risk for HIV/STI by overemphasizing the role of individual sexual risk behaviors. Furthermore, by including social determinants in the modeling, I was able to identify that the risk for HIV/STI was not uniformly distributed across the communities, despite similarities in behavior and relationship dynamics. Thus, the findings from this work help to highlight some of the difficulties that have made the ending the HIV and STI epidemics so elusive among those at greatest risk. Of special note, the tools developed for this dissertation provide an avenue to not only to model risk but may have utility in modeling resilience as well. Addressing the impact of syndemic adversities for black women living with HIV in the US takes a "village" (Dale and Safren 2018). A resource for resilience in the face of the impact of trauma, racism, HIV-stigma, and gender-related stressors, the "village" includes the social support of children, grandchildren, other family members, friends, and partners. It improves adherence to HIV medication, increases the ability to cope with HIV stigma and racism, while creating spaces where these women are agentic and empowered to be seen and experienced as the complete person they are (Harrison and Li 2018). Such an approach addresses experiences along the multiple syndemic levels, while allowing the support and resilience to inform their narratives instead of their adversities.

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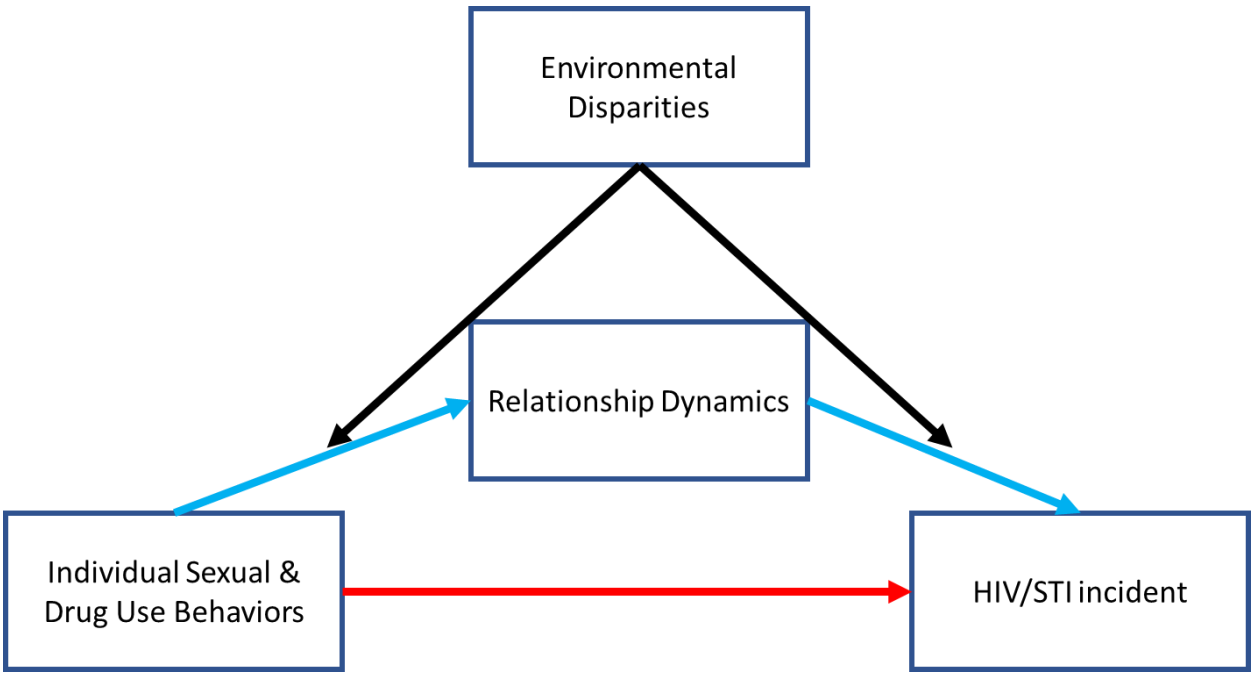
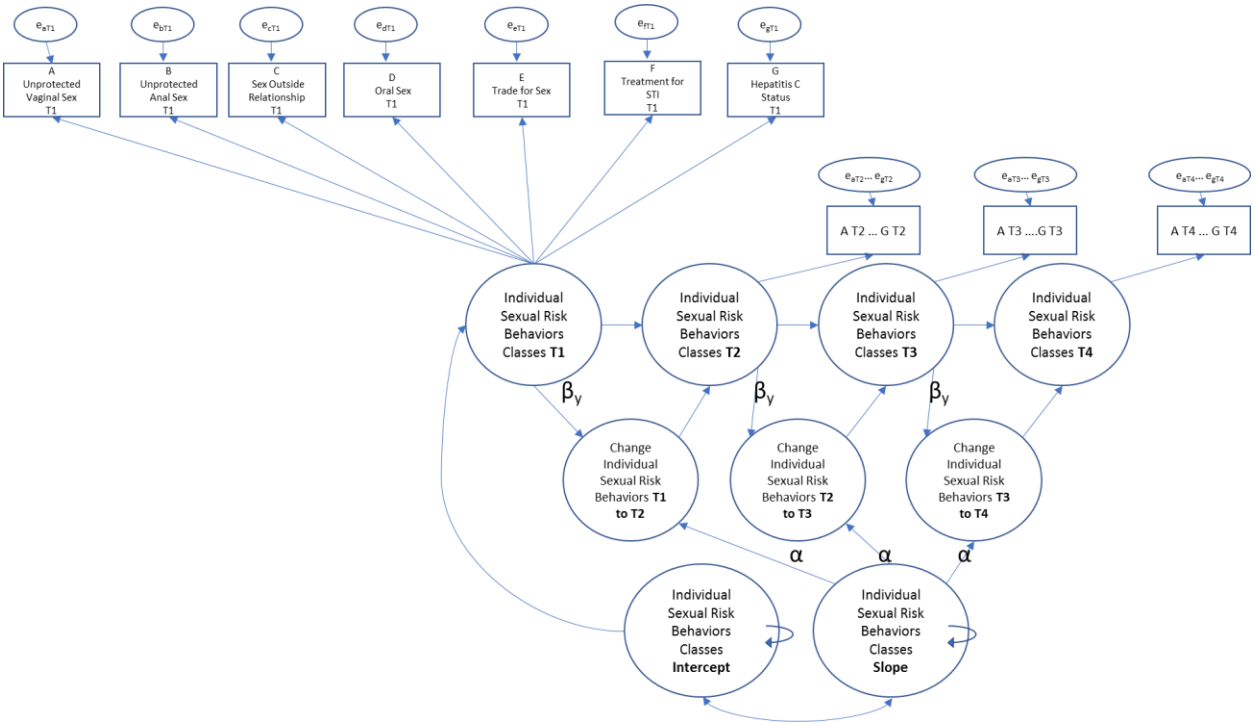
Figures

Figure 1. Conceptual Model



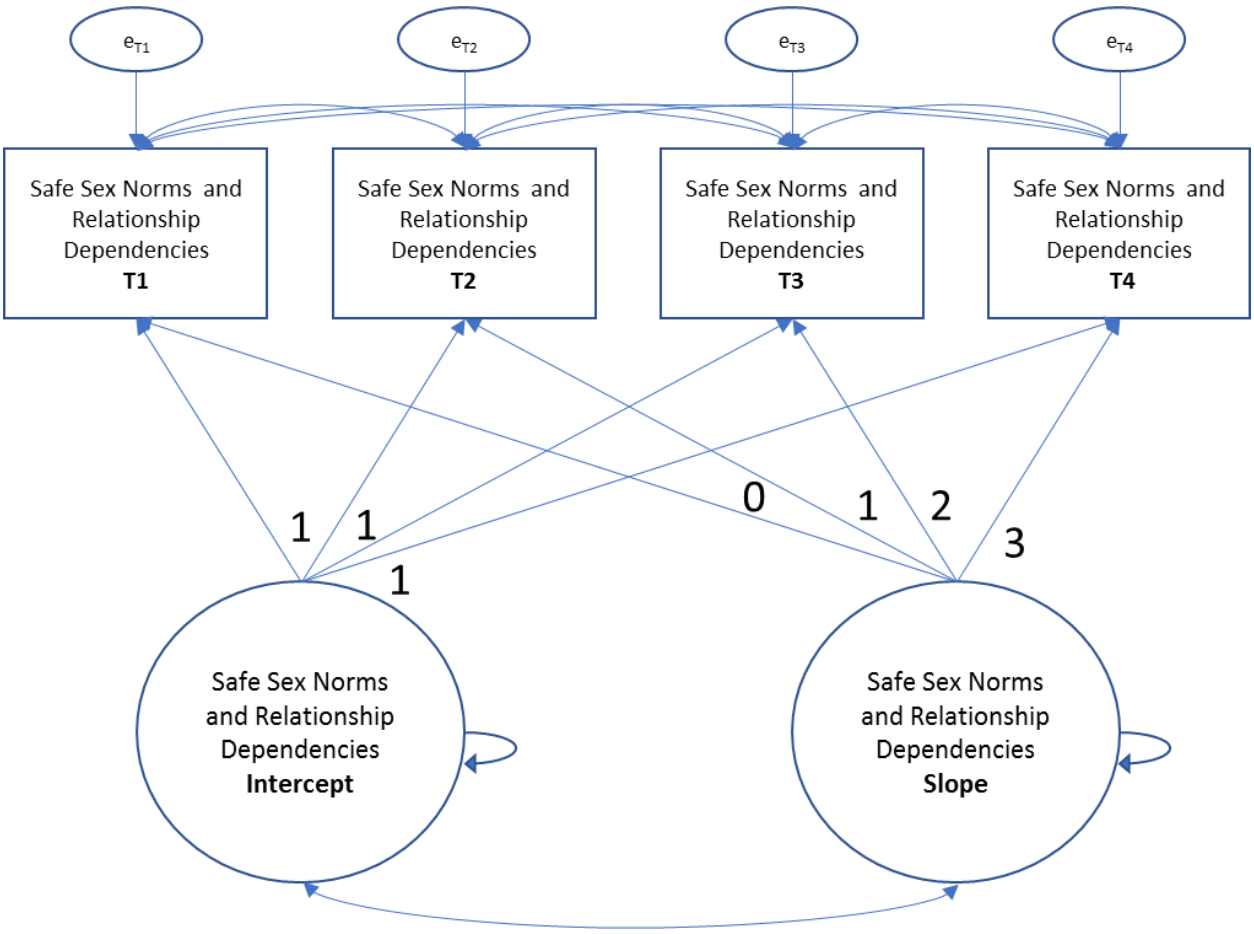
Notes: a) AIM 1 (Red ink); b) AIM 2 (Blue ink); c) AIM 3 (**Black ink**)

Figure 2. AIM 1 using Latent Transition Analyses



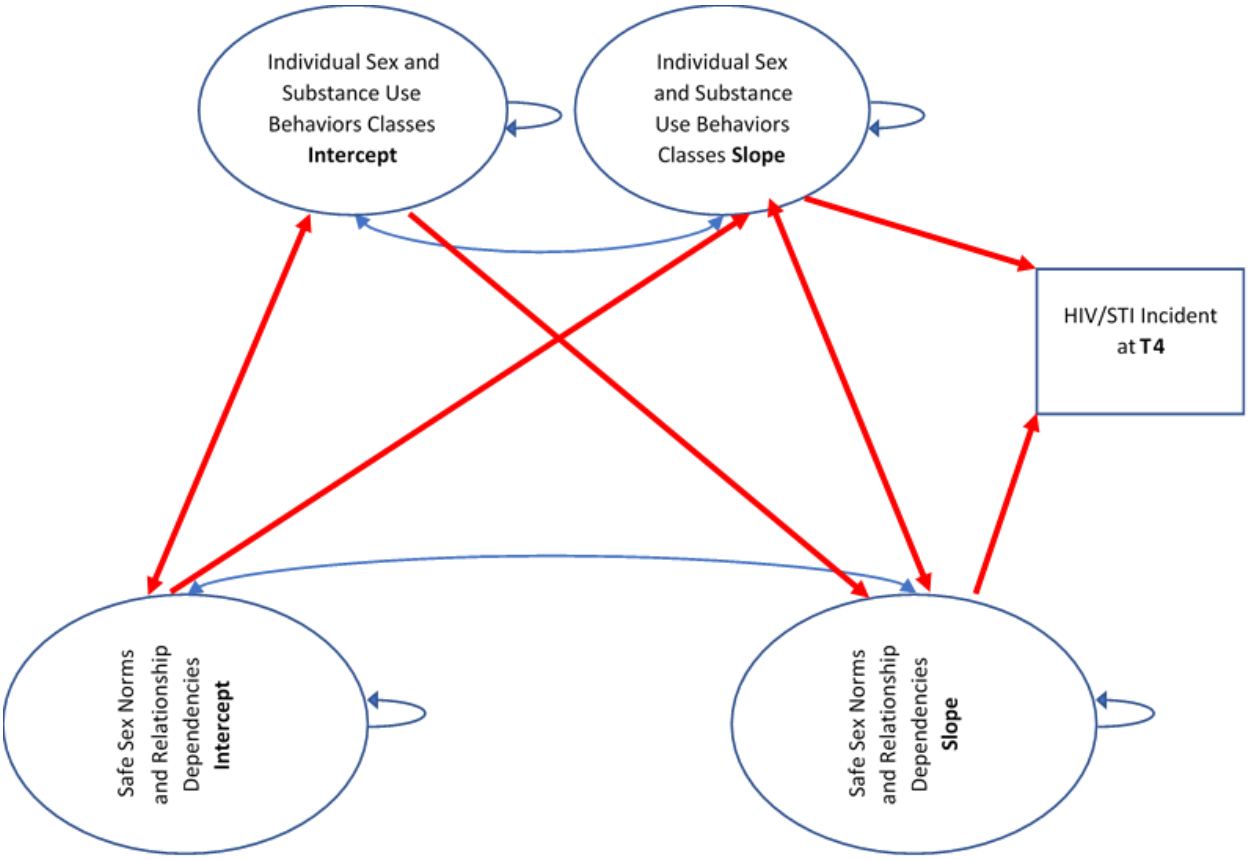
Notes: B_y= Time Invariant proportional coefficient; α= Fix to 1 if linear systemic growth

Figure 3. Latent Growth Mixture Model for Relationship Dynamics



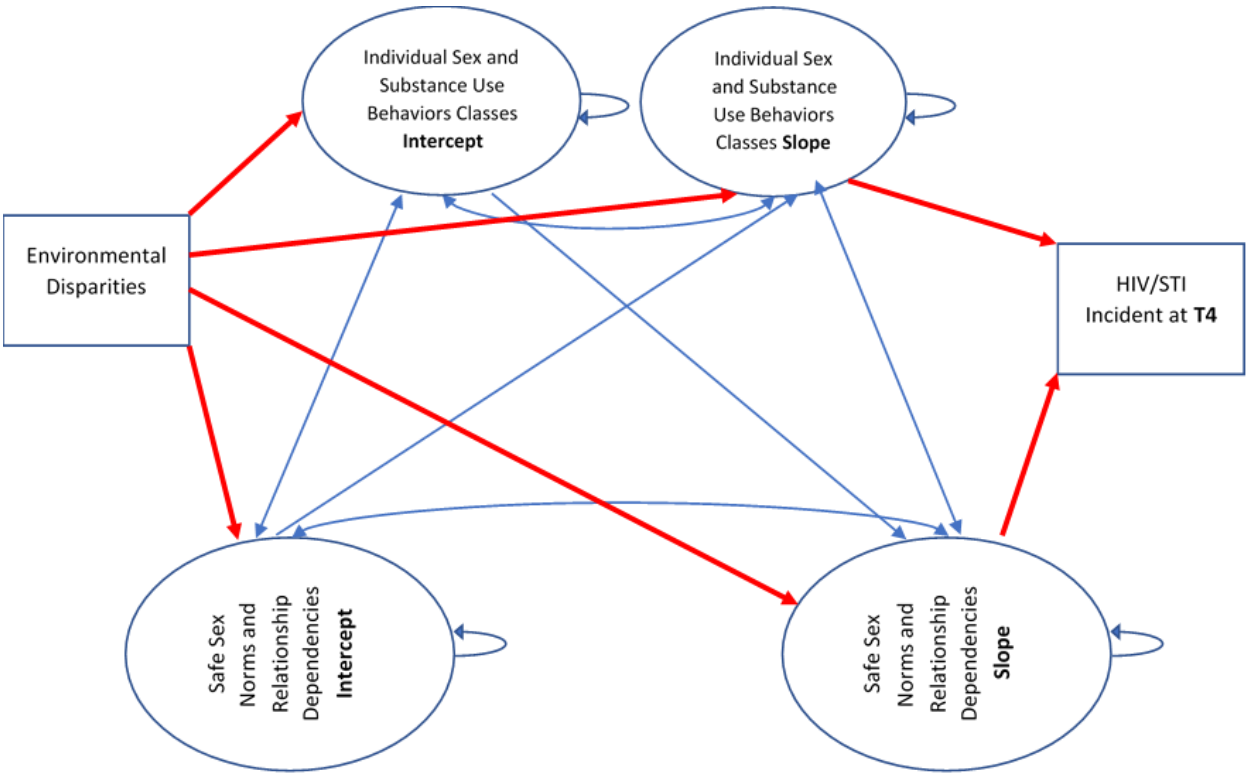
Note: Intercept fixed to 1; 0-3 = Time varying slope of change

Figure 4. Aim 2 using Parallel Process Latent Growth Model to Test Mediation



Note: AIM 2 in red

Figure 5. Aim 3 Using Parallel Process Latent Growth Model to Test Moderation of Mediator



Note: AIM 3 in red

Figure 6. *Latent Class Values and Membership*

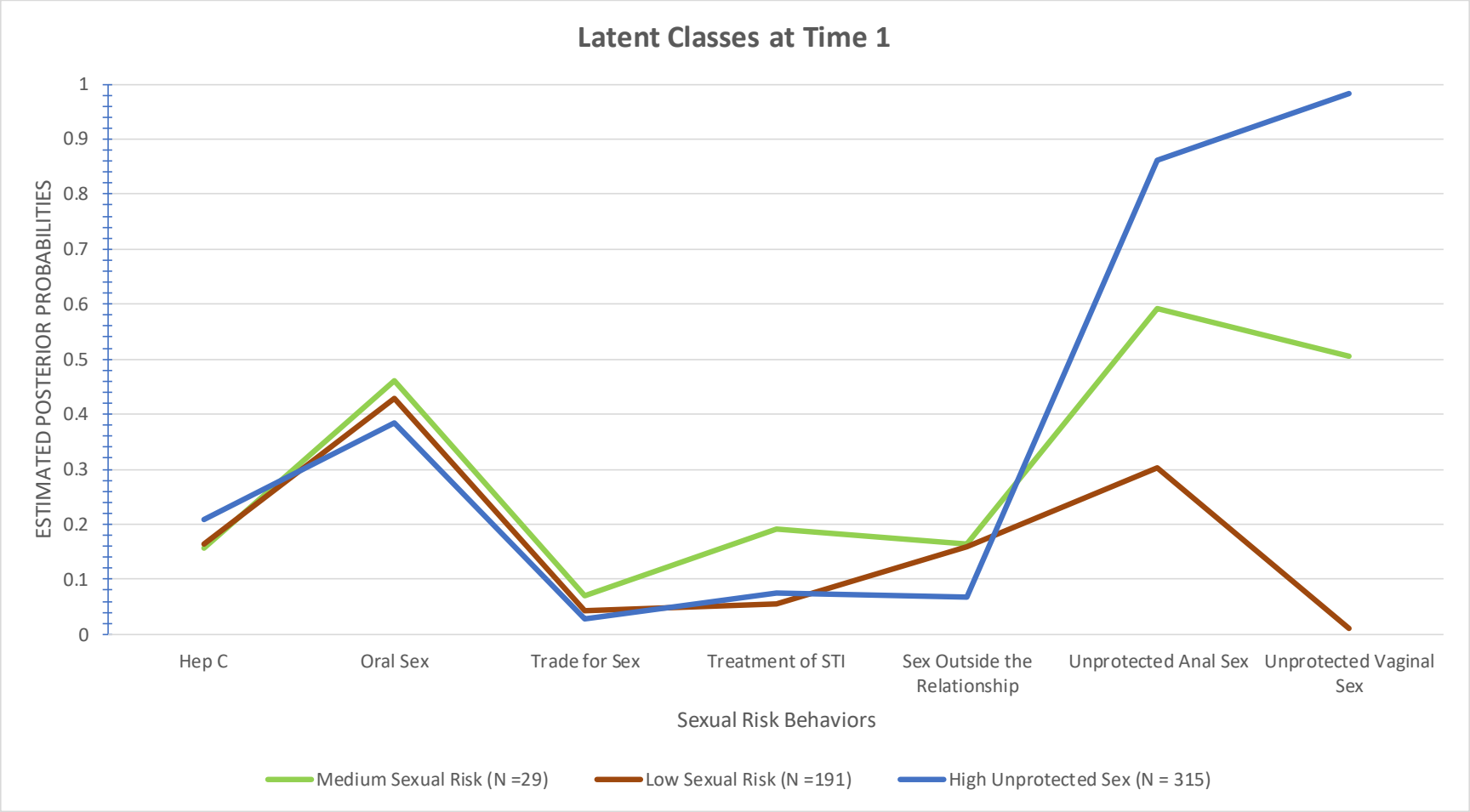


Figure 7. *Sankey Diagram Depicting the Transition Between Latent Classes and Latent Statuses Over Time*

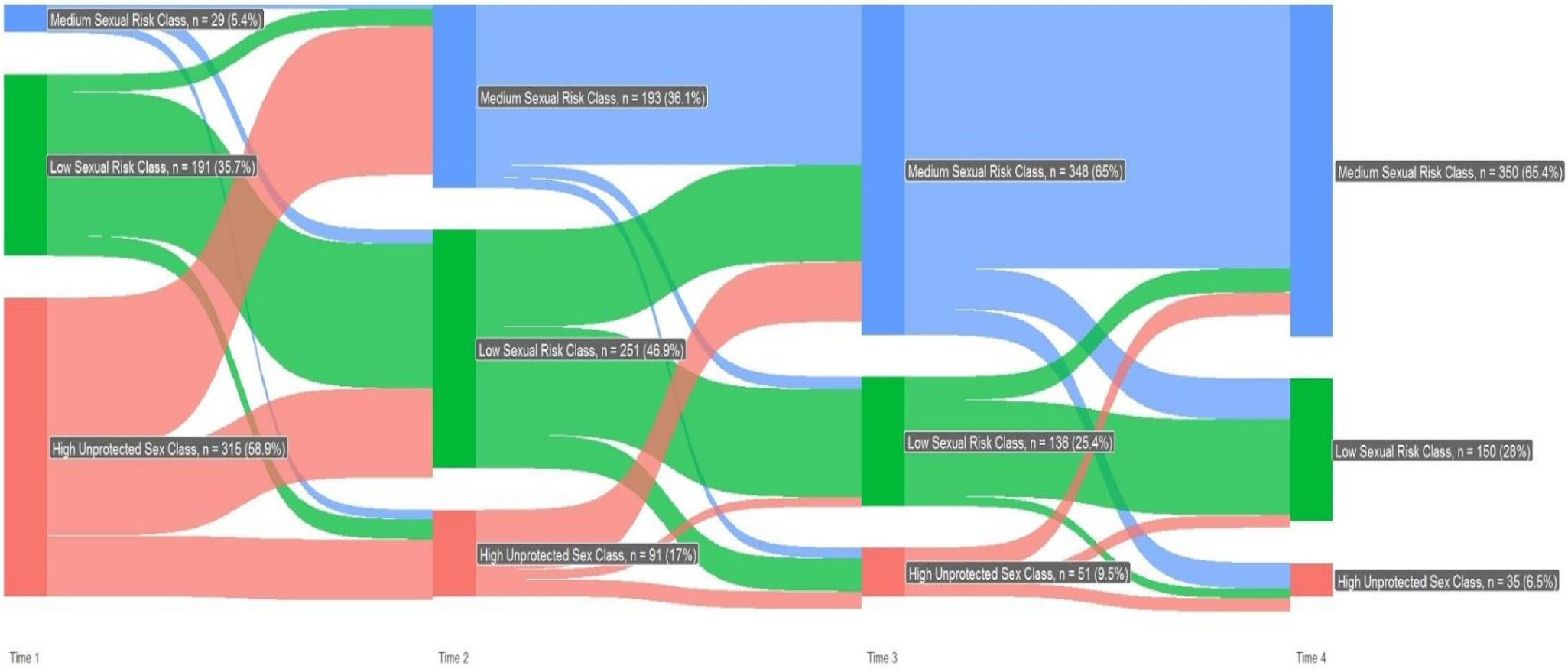


Figure 8. *Unconditional Latent Growth Mixture Model of Combined Couple Relationship Dependencies*

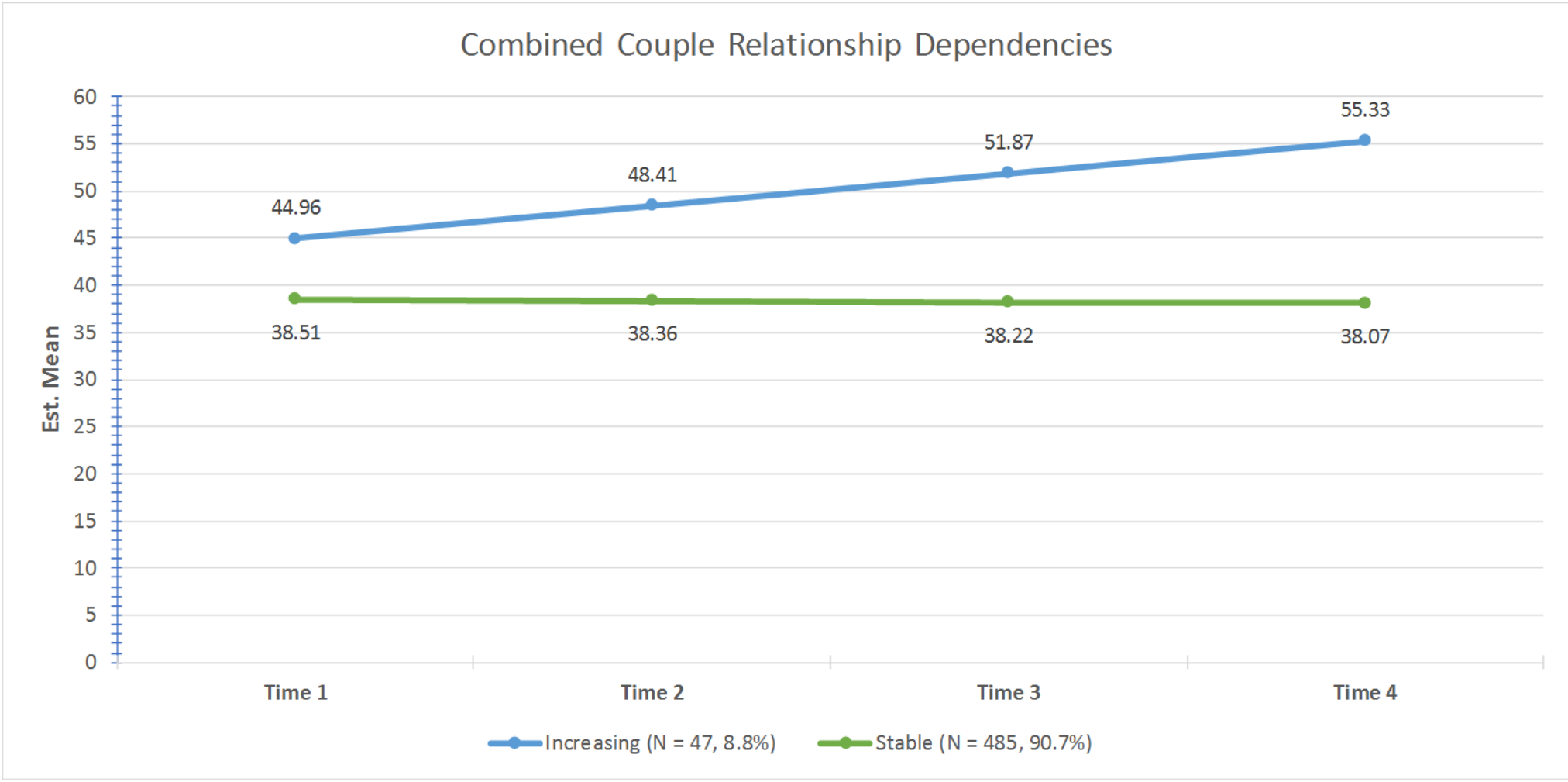
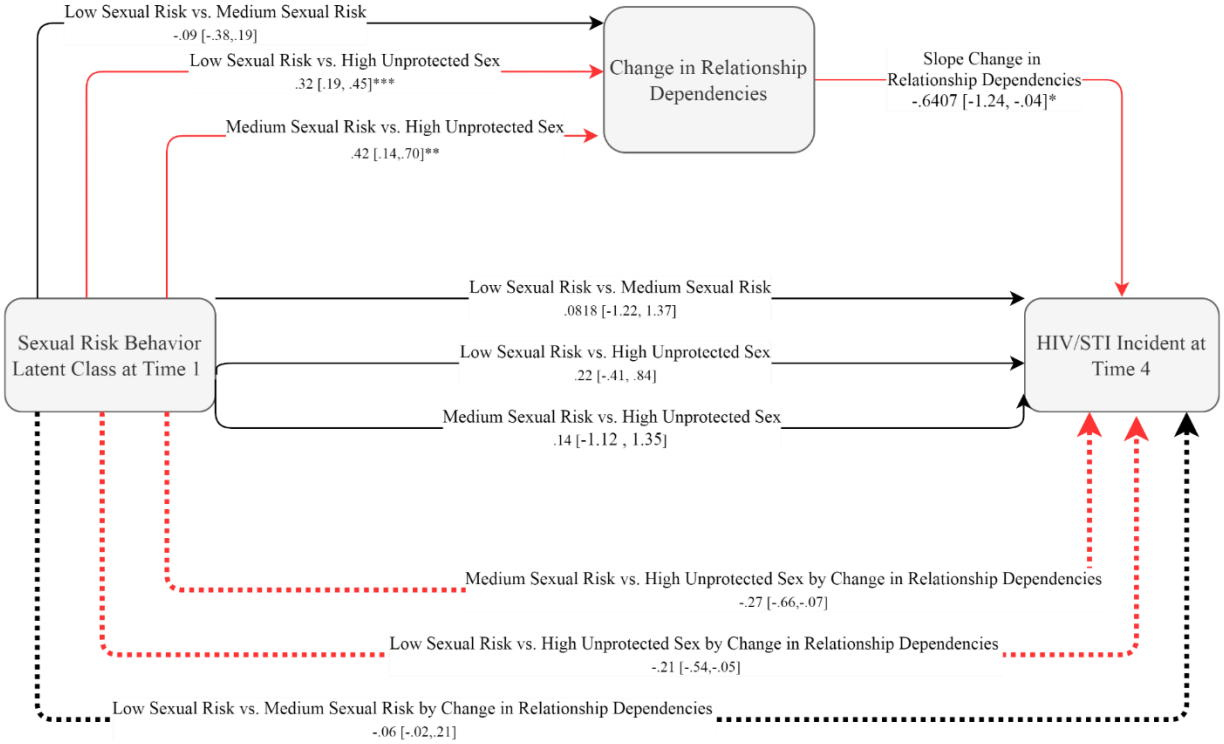
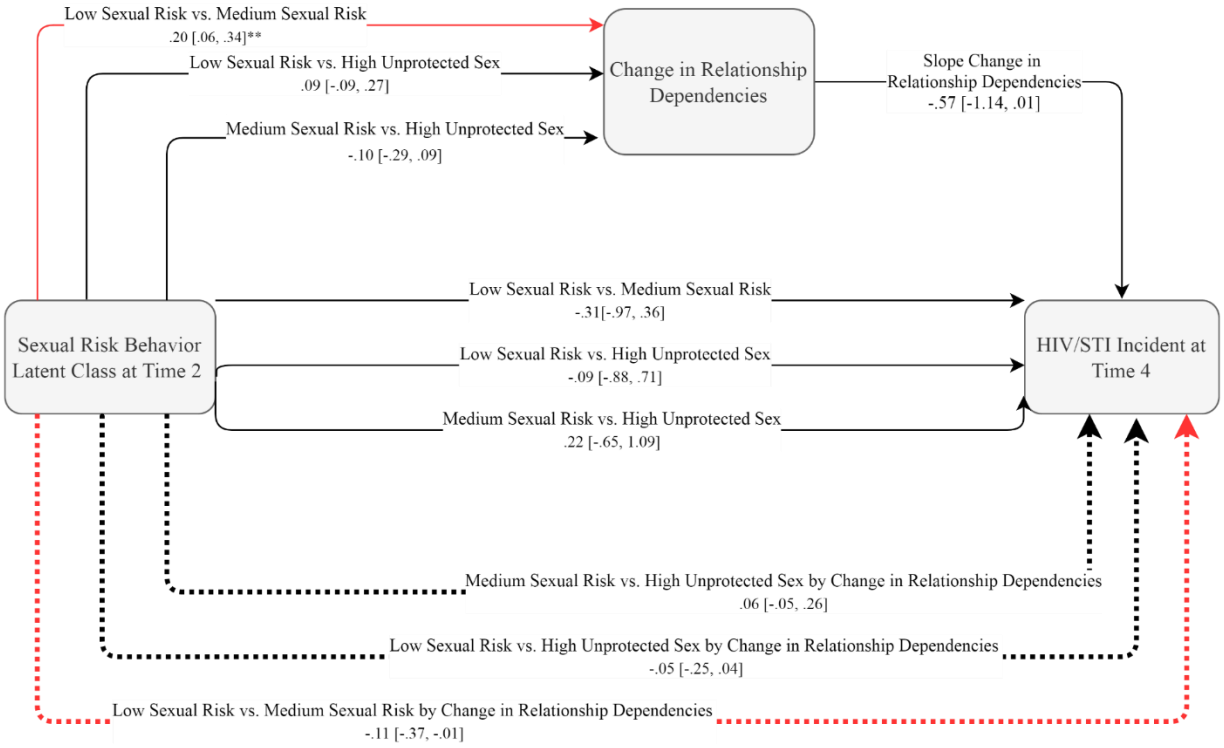


Figure 9. *Mediational Model for Time 1 Sexual Risk Behaviors Latent Classes Mediated by Change in Relationship Dependences on HIV/STI Incident*



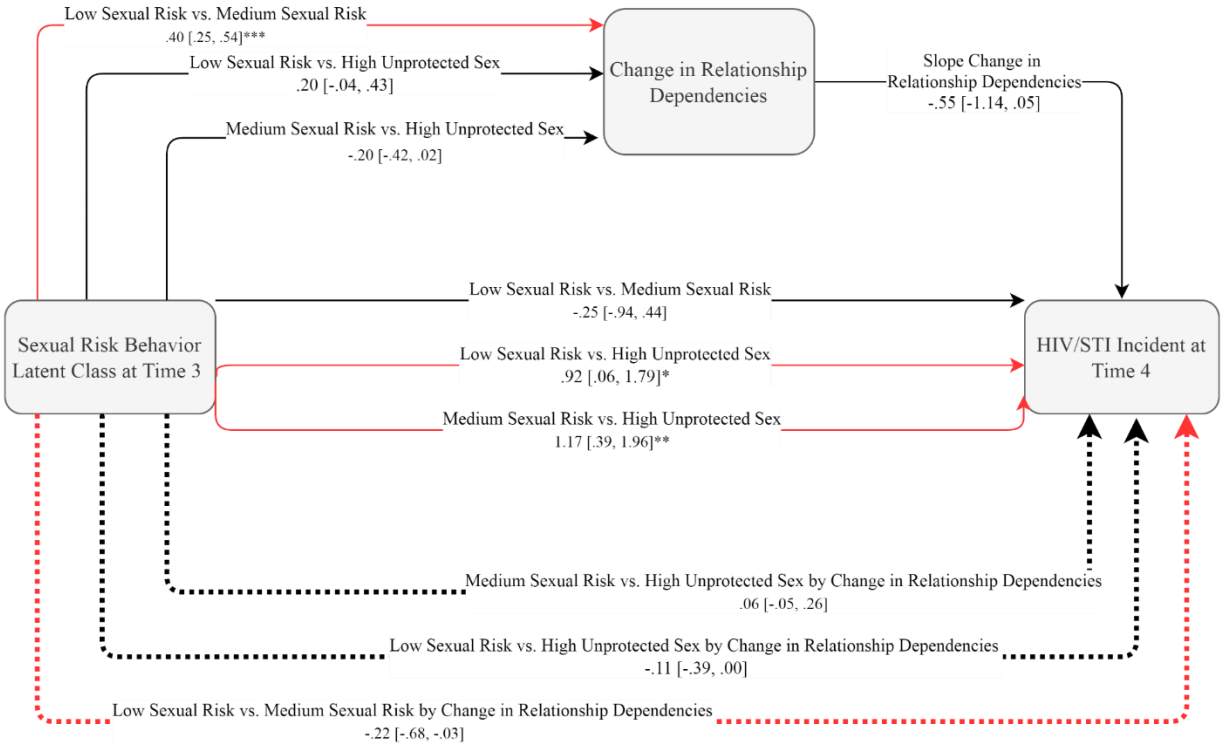
Note: These results are expressed in a log-odds metric; *** p< 0.001, ** p <0.01, * p<0.05; Red line denote significant relationship; dotted line denotes indirect effect

Figure 10. *Mediational Model for Time 2 Sexual Risk Behaviors Latent Class Mediated by Change in Relationship Dependences on HIV/STI Incident*



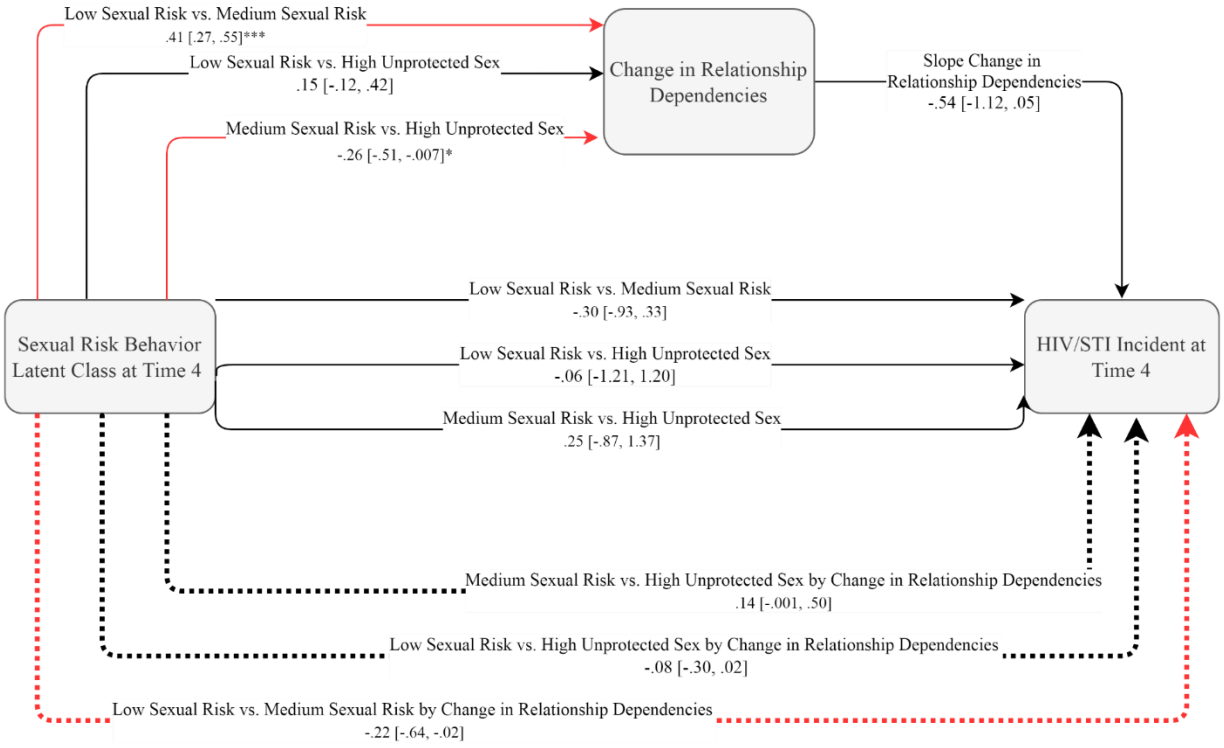
Note: These results are expressed in a log-odds metric; *** p< 0.001, ** p <0.01, * p<0.05; Red line denote significant relationship; dotted line denotes indirect effect

Figure 11. *Mediational Model for Time 3 Sexual Risk Behaviors Latent Class Mediated by Change in Relationship Dependences on HIV/STI Incident*



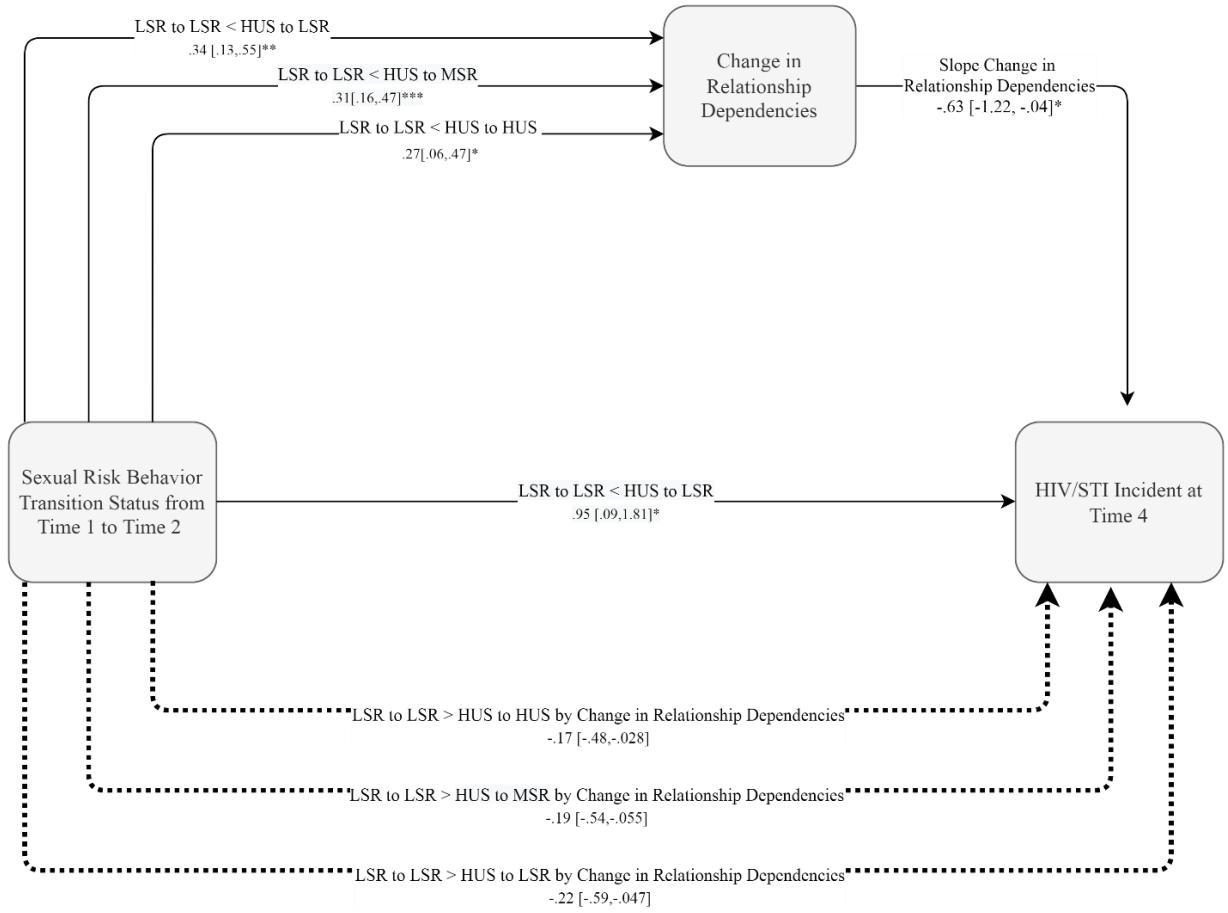
Note: These results are expressed in a log-odds metric; *** p< 0.001, ** p <0.01, * p<0.05; Red line denote significant relationship; dotted line denotes indirect effect

Figure 12. *Mediational Model for Time 4 Sexual Risk Behaviors Latent Class Mediated by Change in Relationship Dependences on HIV/STI Incident*



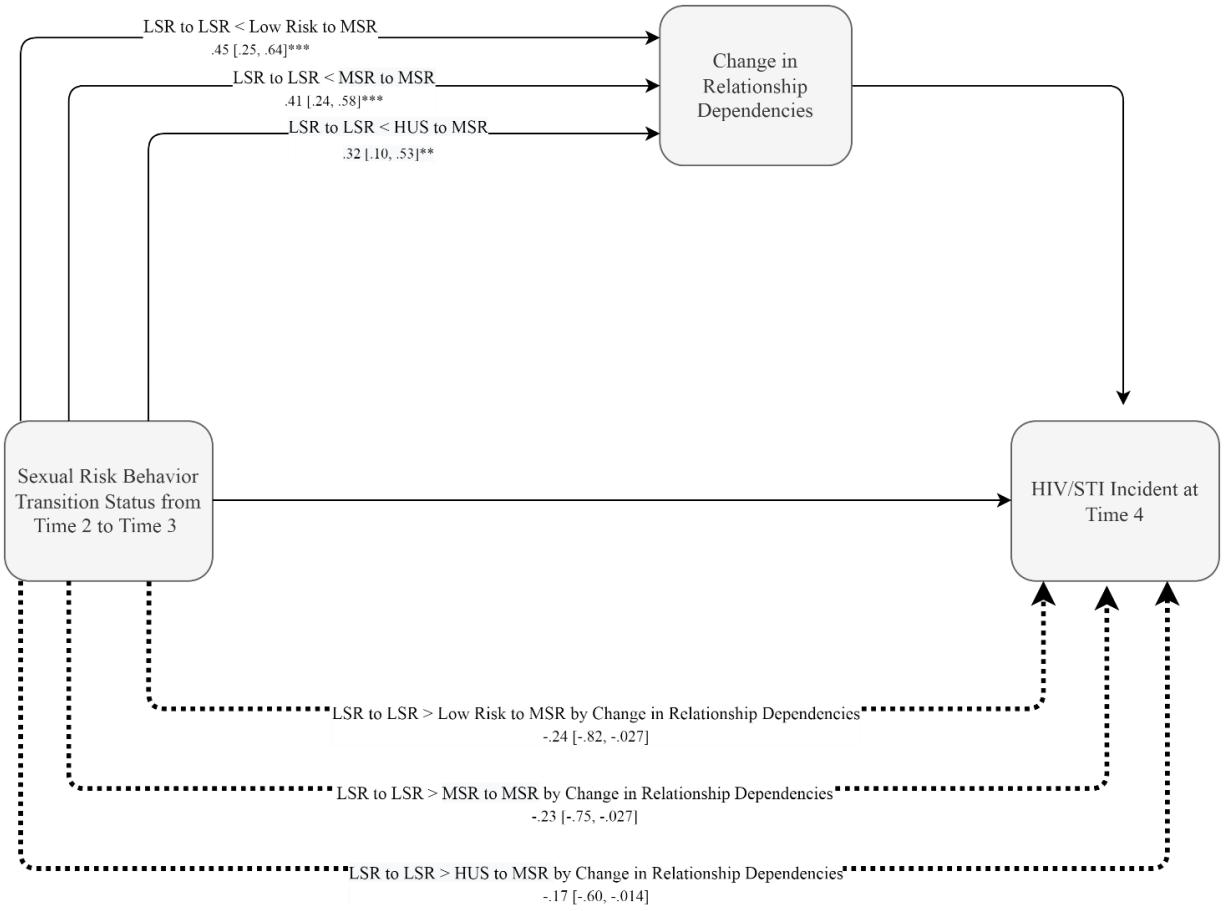
Note: These results are expressed in a log-odds metric; *** p< 0.001, ** p <0.01, * p<0.05; Red line denote significant relationship; dotted line denotes indirect effect

Figure 13. *Mediational Model for Sexual Risk Behaviors Latent Transition Status from Time 1 to Time 2, Mediated by Change in Relationship Dependences on HIV/STI Incident*



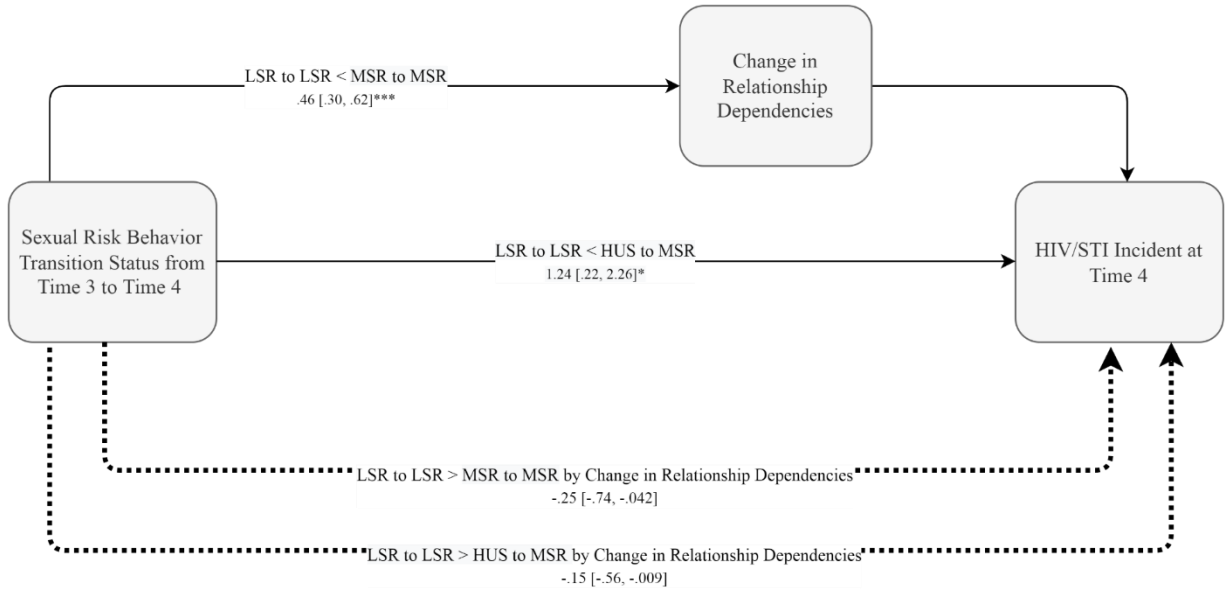
Note: LSR = Low Sexual Risk; MSR = Medium Sexual Risk; HUS = High Unprotected Sex; Reference category is individual who stayed in the Low Sexual Risk class from Time 1 to Time 2; Only significant paths illustrated; These results are expressed in a log-odds metric; *** p< 0.001, ** p <0.01, * p<0.05; dotted line denotes indirect effect

Figure 14. *Mediational Model for Sexual Risk Behaviors Latent Transition Status from Time 2 to Time 3, Mediated by Change in Relationship Dependences on HIV/STI Incident*



Note: LSR = Low Sexual Risk; MSR = Medium Sexual Risk; HUS = High Unprotected Sex; Reference category is individual who stayed in the Low risk class from Time 2 to Time 3; Only significant paths illustrated; These results are expressed in a log-odds metric; *** p< 0.001, ** p <0.01, * p<0.05; dotted line denotes indirect effect

Figure 15. *Mediational Model for Sexual Risk Behaviors Latent Transition Status from Time 3 to Time 4, Mediated by Change in Relationship Dependences on HIV/STI Incident*



Note: LSR = Low Sexual Risk; MSR = Medium Sexual Risk; HUS = High Unprotected Sex; Reference category is individual who stayed in the Low risk class from Time 3 to Time 4; Only significant paths illustrated; These results are expressed in a log-odds metric; *** p< 0.001, ** p <0.01, * p<0.05; dotted line denotes indirect effect

Tables

Table 1. *Sample and Latent Class Sociodemographic Characteristics*

Variable	Total Sample		Low Sexual Risk		Medium Sexual Risk		High Unprotected Sex		Significant Differences [c]
	N = 535	%	N = 191	%	N = 29	%	N = 315	%	
Age: M (SD)	41.7297 (7.67576)		41.0267 (7.40345)		38.4286 (8.23465)		42.442 (7.69330)		High > Mid and Low**
Education									
No formal schooling	9	1.7%	8	4.2%	0	0.0%	1	0.3%	Not significant
Less than a high school diploma	176	32.9%	65	34.4%	11	37.9%	100	31.8%	Not significant
A high school diploma or (GED)	188	35.1%	62	32.8%	11	37.9%	115	36.6%	Not significant
Some college or a 2-year degree	135	25.2%	45	23.8%	6	20.7%	84	26.8%	Not significant
4-year college degree	20	3.7%	8	4.2%	1	3.4%	11	3.5%	Not significant
Post-graduate work	4	0.7%	1	0.5%	0	0.0%	3	1.0%	Not significant
Marital Status	209	39.1%	79	41.8%	12	41.4%	118	37.7%	Not significant
Unemployment Status	409	76.4%	156	82.5%	20	69.0%	233	74.7%	Not significant
Income (per month)									
Less than $400	149	27.9%	55	29.1%	4	13.8%	90	28.8%	Not significant
$ 400 - $ 850	234	43.7%	87	46.0%	15	51.7%	132	42.3%	Not significant
$ 851 - $1650	102	19.1%	37	19.6%	8	27.6%	57	18.3%	Not significant
$1651 - $2500	32	6.0%	7	3.7%	2	6.9%	23	7.4%	Not significant
$2501 - $3300	4	0.7%	1	0.5%	0	0.0%	3	1.0%	Not significant
$3301 - $4100	6	1.1%	2	1.1%	0	0.0%	4	1.3%	Not significant
$4101 or more	3	0.6%	0	0.0%	0	0.0%	3	1.0%	Not significant
Health insurance	435	81.9%	153	81.0%	24	82.8%	258	82.4%	Not significant

Prison Incarceration History	256	47.9%	101	53.7%	13	44.8%	142	45.8%	Low > Mid**
Substance Use Disorder Treatment									
Inpatient treatment	266	49.7%	112	59.6%	9	31.0%	145	46.2%	High > Mid*
Residential treatment	138	25.8%	58	30.7%	5	17.2%	75	24.0%	Not significant
City/Site									
New York City, NY	221	41.3%	70	36.6%	16	55.2%	135	42.9%	High > Low*
Atlanta, GA	117	21.9%	34	17.8%	9	31.0%	74	23.5%	High > Low*
Philadelphia, PA	97	18.1%	50	26.2%	4	13.8%	43	13.7%	High > Low*
Los Angeles, CA	100	18.7%	37	19.4%	0	0.0%	63	20.0%	Low and High > Mid***
Treatment Arm									
EBAN	260	48.6%	78	40.8%	14	48.3%	168	53.3%	Not significant
Wellness	275	51.4%	113	59.2%	15	51.7%	147	46.7%	Not significant
Times injected heroin, cocaine or any other drugs [a]	.3733 (2.63883)		.4731 (2.90607)		.5172 (2.04626)		.3000 (2.52181)		Not significant
Times shared needles, cookers, or cotton while injecting illegal drugs [a]	.0551 (.70832)		.0968 (.93652)		.0000		.0354 (.56969)		Not significant
Sexual Transmitted Infections									
Chlamydia	4	0.8%	1	0.5%	0	0%	3	1.0%	Not significant
Gonorrhea	1	0.2%	0	0%	0	0%	1	0.2%	Not significant
Trichomoniasis	116	21.8%	46	24.3%	6	20.7%	64	20.4%	Not significant
PTSD Symptoms: M (SD)	31.2557 (13.35754)		32.8043 (14.29986)		32 (12.05642)		30.2701 (12.83459)		Not significant
For HIV Positive Participants (n = 323; 60.4%)									
Time known HIV+ [b]	8.7526 (5.17554)		8.5635 (4.84037)		7.2817 (4.40608)		9.0627 (5.46914)		Not significant
CD4 lymphocyte count									

0-199	23	4.3%	9	7.4%	1	4.8%	13	7.6%	Not significant
200-500	98	18.3%	39	32.2%	3	14.3%	56	32.7%	Not significant
501-3000	103	19.3%	41	33.9%	9	42.9%	53	31.0%	Not significant
Viral Load									
0-50	78	14.6%	35	28.7%	4	20.0%	39	23.2%	Not significant
51-400	25	4.7%	11	9.0%	1	5.0%	13	7.7%	Not significant
>400	71	13.3%	29	23.8%	4	20.0%	38	22.6%	Not significant

Note: a = in the last 3 months; b = years; c = Post-hoc Tukey's honestly significant difference (HSD);* $p < 0.05$, ** $p < 0.01$, and *** $p \leq 0.001$

Table 2. *Latent Class Analysis Model Fit Statistics*

Number of Classes	AIC	BIC	SSABIC	Entropy	LMR	LMR p value	BLRT p value
Time 1							
Class 2	2063.979	2162.471	2089.462	0.651	444.741	0	0
Class 3	1765.005	1910.602	1802.675	0.759	316.396	**0.0255**	0
Class 4	1414.901	1607.603	1464.759	**0.801**	366.795	0.3311	0
Class 5	1133.991	**1373.798**	**1196.036**	**0.827**	299.247	0.9398	0
Class 6	**1130.996**	1417.908	1205.229	**0.81**	249.66	0.987	0
Class 7	1150.364	1484.38	1236.783	**0.811**	2.605	0	1
Time 2							
Class 2	2563.411	2653.22	2586.56	**0.888**	398.338	0	0
Class 3	2199.543	2332.119	2233.716	**0.935**	377.848	0	0
Class 4	2070.837	2246.179	2116.033	**0.943**	146.374	**0.0064**	0
Class 5	1934.019	2152.128	1990.238	**0.942**	154.359	0.111	0
Class 6	1847.981	**2108.856**	1915.224	**0.945**	87.29	0.0453	0
Class 7	**1830.081**	2133.722	**1908.347**	**0.93**	-12.383	0.5047	1
Time 3							
Class 2	2083.154	2155.952	2101.989	0.762	461.308	**0**	0
Class 3	1790.654	1897.711	1818.353	0.783	302.481	**0.003**	0
Class 4	1613.08	1754.395	1649.643	**0.803**	189.797	**0.0176**	0
Class 5	1561.183	1736.756	1606.608	0.792	66.573	0.2675	0
Class 6	1425.112	1634.943	1479.401	0.792	53.112	0.3713	0
Class 7	**1379.715**	**1623.804**	**1442.868**	0.759	112.126	0.8447	0
Class 8	**1276.681**	**1555.028**	**1348.697**	**0.798**	**72.235**	**0.3894**	0
Time 4							
Class 2	1909.916	1988.655	1928.354	0.742	460.296	0	0
Class 3	1547.902	1663.939	1575.073	0.794	373.264	0.0022	0

Class 4	1405.938	1559.273	1441.843	**0.816**	157.122	0.1459	0
Class 5	1302.165	1492.798	1346.804	**0.837**	119.61	0.1091	0
Class 6	**1221**	**1448.93**	**1274.373**	**0.846**	84.453	0.2022	0
Class 7	1259.096	1524.324	1321.202	0.719	40.855	0.6253	0

Note: Bold indicates lowest value for statistics; AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; SSABIC = Sample Size Adjusted Bayesian Information Criterion; BLRT = Bootstrapped Likelihood Ratio Test; LMR = Lo-Mendell-Rubin test. * Yielded classes with less than 20% of the sample.

Table 3. *Description and Significance Test for Three-Class Latent Class Analyses*

Sexual Risk Behaviors	Total Sample		Low Sexual Risk		Medium Sexual Risk		High Unprotected Sex		Significance Latent Class Comparisons [a]
	N = 535	%	N = 191	%	N = 29	%	N = 315	%	
Hepatitis C positive	97	18.1%	39	20.6%	5	17.2%	53	16.9%	Not significant
Engaged in oral sex	339	63.4%	127	67.2%	27	93.1%	185	59.1%	Mid > Low* > High**
Exchanged sex for drugs, money, shelter, or food	27	5.0%	12	6.4%	4	13.8%	11	3.5%	Low and Mid > High*
Received treatment for STI	45	8.4%	11	5.8%	2	6.9%	32	10.2%	Not significant
Engaged in sex outside the relationship	52	9.7%	15	7.9%	5	17.2%	32	10.2%	Not significant
Proportion of unprotected anal sex (n = 82)	37.20% (SD = 42.605%)		14.25% (SD = 28.475%)		34.76% (SD = 26.795%)		54.68% (SD = 45.657%)		High > Low ***
Proportion of unprotected vaginal sex (n = 506)	42.29% (SD = 42.747%)		10.44% (SD = 25.799%)		34.20% (SD = 34.304%)		63.54% (SD = 39.139%)		High > Mid*** > Low**

Note: all behaviors assess in past 90 days; a = Post-hoc Tukey's HSD; * $p < 0.05$, ** $p < 0.01$, and *** $p \leq 0.001$

Table 4. *Latent Transitional Probabilities Based on Estimated Model Depicting Proportion of Sample Transitioning at Each Time Point*

Time 1	Time 2		
	Low Sexual Risk	Medium Sexual Risk	High Unprotected Sex
Low Sexual Risk	0.798	0.095	0.108
Medium Sexual Risk	0.527	0.127	0.346
High Unprotected Sex	0.3	0.498	0.203
Time 2	*Time 3*		
	Low Sexual Risk	Medium Sexual Risk	High Unprotected Sex
Low Sexual Risk	0.455	0.407	0.137
Medium Sexual Risk	0.065	0.877	0.058
High Unprotected Sex	0.106	0.692	0.203
Time 3	Time 4		
	Low Sexual Risk	Medium Sexual Risk	High Unprotected Sex
Low Sexual Risk	0.744	0.187	0.07
Medium Sexual Risk	0.123	0.8	0.076
High Unprotected Sex	0.255	0.468	0.277

Table 5. *Fit Indices for One-To-Four-Class Unconditional Growth Mixture Models of Couple Relationship Dependencies (N = 535)*

Fit Index	One-Class	Two-Classes	Three-Classes	Four-Classes
AIC[a]	28272.596	28245.92	28240.004	28234.916
BIC[b]	28307.392	28295.627	28304.623	28314.448
SSBIC[c]	28285.158	28263.866	28263.333	28263.629
Entropy	-	0.614	0.645	0.695
LRT[d]	-	0.0121	0.0851	0.0239

a AIC = Akaike Information Criterion; b BIC = Bayesian Information Criterion; cSSBIC = Sample-size adjusted Bayesian Information Criterion; dLRT = Lo-Mendell-Rubin test

Table 6. *Indirect Effect of Different Levels of Moderator on Mediation of Relationship Dependencies on Association Between Sexual Risk Behavior Latent Status from Time 1 to Time 2 on HIV/STI Incident*

Variable	Transition Status	Time 1 to Time 2 Paths			
		Indirect Effect	Standard Error	95% CI Lower	95% CI Upper
Average change in number of people diagnosed with HIV					
-830 (16th %tile)		Non-Significant			
	HUS to LSR	-.1972	.1499	-.6112	-.0323
-61 (50th %tile)	HUS to MSR	-.2079	.1537	-.6351	-.0527
	HUS to HUS	-.1625	.1338	-.5331	-.0219
	HUS to LSR	-.5058	.3870	-1.5235	-.0621
920 (84th %tile)	HUS to MSR	-.2610	.2222	-.8353	-.0105
	HUS to HUS	-.4228	.3710	-1.4550	-.0133
Average change in number of people diagnosed with AIDS					
	MSR to MSR	.0806	.3174	.0113	1.1518
	MSR to HUS	.0995	.1364	.0058	.4792
-240.67 (16th %tile)	HUS to LSR	-.2271	.2353	-.9097	-.0336
	HUS to MSR	-.2473	.2417	-.9705	-.0542
	HUS to HUS	-.2336	.2742	-1.0667	-.0342
	HUS to LSR	-.2113	.1835	-.6999	-.0383
-15.67 (50th %tile)	HUS to MSR	-.1757	.1573	-.6195	-.0369
	HUS to HUS	-.1489	.1472	-.5450	-.0187
126.33 (84th %tile)		Non-Significant			
Average change in number of people diagnosed with Chancroid					
-1 (16th %tile)	MSR to MSR	.1506	.1240	.0184	.4841
	HUS to LSR	-.4190	.3798	-1.4563	-.0157

0 (50th %tile)	HUS to LSR	-.1824	.1454	-.5580	-.0272
	HUS to HUS	-.1645	.1377	-.5438	-.0207
.33 (84th %tile)	HUS to HUS	-.1583	.1571	-.5890	-.0013
Average change in the percent of people living below the poverty level					
-6.7% (16th %tile)	HUS to LSR	-.4118	.3446	-1.3378	-.0229
3.3% (50th %tile)	HUS to LSR	-.2684	.2169	-.8785	-.0529
	HUS to MSR	-.2327	.1824	-.7579	-.0661
	HUS to HUS	-.2114	.1910	-.7402	-.0282
16.7% (84th %tile)	Non-Significant				
Average change in the number of violent crimes					
-1200.67 (16th %tile)	Non-Significant				
-.544 (50th %tile)	HUS to HUS	-.1936	.2288	-.8345	-.0254
111.67 (84th %tile)	HUS to HUS	-.1481	.1367	-.5242	-.0199
Average change in the number of individuals under parole per 100,000 residents					
-6.33 (16th %tile)	Non-Significant				
-2.67 (50th %tile)	HUS to LSR	-.2552	.1887	-.7869	-.0479
	HUS to HUS	-.2007	.1653	-.6483	-.0399
1.33 (84th %tile)	HUS to LSR	-.2621	.2445	-.9652	-.0305
	HUS to HUS	-.2496	.2203	-.8584	-.0249
Average change in the number of inmates held in jail					
-212.33 (16th %tile)	MSR to MSR	.1800	.1582	.0228	.6221
	HUS to MSR	-.3444	.2776	-1.1213	-.0431
37.67 (50th %tile)	HUS to LSR	-.2107	.1699	-.6927	-.0390
	HUS to MSR	-.1908	.1484	-.6190	-.0505
	HUS to HUS	-.1604	.1437	-.5815	-.0251
171.67 (84th %tile)	Non-Significant				
Average change in the number of individuals per 100,000, seeking substance use treatment					

-14.33 (16th %tile)			Non-Significant		
	HUS to LSR	-.3027	39303.56	-1.0429	-.0314
-2.67 (50th %tile)	HUS to MSR	-.2637	39303.56	-.8646	-.0682
	HUS to HUS	-.2414	39303.56	-.7866	-.0357
56.33 (84th %tile)	HUS to MSR	-.2750	2515428.10	-.9407	-.0344
	HUS to HUS	-.2782	2515428.10	-.9227	-.0023

Note: LSR = Low Sexual Risk; MSR = Medium Sexual Risk; HUS = High Unprotected Sex; Low Sexual Risk to Low Sexual Risk class is reference category for each time point; 95% CI = 95% Confidence Interval

Table 7. *Indirect Effect of Different Levels of Moderator on Mediation of Relationship Dependencies on Association Between Sexual Risk Behavior Latent Status from Time 2 to Time 3 on HIV/STI Incident*

Variable	Transition Status	Time 2 to Time 3 Paths			
		Indirect Effect	Standard Error	95% CI Lower	95% CI Upper
Average change in number of people diagnosed with HIV					
Increase		Non-Significant			
Decrease	MSR to HUS	.2160	.2677	.0409	1.0212
Average change in the number of people diagnoses with Syphilis					
Increase		Non-Significant			
Decrease	LSR to MSR	-.6989	.4128	-1.8885	-.2754
	HUS to MSR	-.4775	.3056	-1.3476	-.1498
Average change in number of people diagnosed with Chancroid					
-1 (16th %tile)		Non-Significant			
0 (50th %tile)	LSR to MSR	-.2435	.2102	-.8304	-.0325
	MSR to MSR	-.2326	.2072	-.8034	-.0320
	MSR to HUS	-.3026	.3799	-1.3898	-.0154
	HUS to MSR	-.1853	.1807	-.6933	-.0196
.33 (84th %tile)	LSR to MSR	-.2460	.2248	-.8767	-.0166
	MSR to MSR	-.2422	.2351	-.9039	-.0168
	MSR to HUS	-.4011	.5304	-1.9484	-.0142
	HUS to MSR	-.2206	.2319	-.8771	-.0135
Average change in the percent of people living below the poverty level					
-6.7% (16th %tile)	LSR to MSR	-.7350	.5783	-2.3695	-.1599
	MSR to MSR	-.4176	.3405	-1.3968	-.0790
	MSR to HUS	-.6727	2.1466	-6.4485	-.0814
	HUS to MSR	-.4120	.3711	-1.4444	-.0653

	LSR to MSR	-.3469	.3040	-1.2205	-.0725
3.3% (50th %tile)	MSR to MSR	-.2948	.2582	-1.0298	-.0630
	HUS to MSR	-.2373	.2295	-.9168	-.0381
16.7% (84th %tile)			Non-Significant		
Average change in the number of violent crimes					
	LSR to MSR	-.2294	.3076	-1.1798	-.0156
-1200.67 (16th %tile)	MSR to MSR	-.2197	.2795	-1.0751	-.0135
	HUS to MSR	-.1934	.2581	-.9632	-.0098
	LSR to MSR	-.2287	.2197	-.8773	-.0311
-.544 (50th %tile)	MSR to MSR	-.2098	.2046	-.7857	-.0298
	HUS to MSR	-.1360	.1471	-.5764	-.0113
111.67 (84th %tile)			Non-Significant		
Average change in the number of individuals under parole per 100,000 residents					
-6.33 (16th %tile)			Non-Significant		
-2.67 (50th %tile)	HUS to MSR	-.2405	.1946	-.7934	-.0474
1.33 (84th %tile)	HUS to MSR	-.3288	.2798	-1.1363	-.0666
Average change in the number of inmates held in jail					
-212.33 (16th %tile)			Non-Significant		
	LSR to MSR	-.2353	.2236	-.9085	-.0339
37.67 (50th %tile)	MSR to MSR	-.2177	.2075	-.8378	-.0319
	MSR to HUS	-.3676	.7693	-2.0473	-.0131
	HUS to MSR	-.1658	.1706	-.6748	-.0196
171.67 (84th %tile)			Non-Significant		
Average change in the number of inmates held in prisons					
-758.67 (16th %tile)			Non-Significant		
	LSR to MSR	-.2678	.2456	-.9607	-.0208
-92.67 (50th %tile)	MSR to MSR	-.2286	.2162	-.8377	-.0180
	HUS to MSR	-.1744	.1742	-.6605	-.0101

1347.67 (84th %tile)	MSR to MSR	-.3100	.3628	-1.3729	-.0079
Average change in the number of individuals per 100,000, seeking substance use treatment					
	LSR to MSR	-.5063	.4273	-1.7427	-.1119
-14.33 (16th %tile)	MSR to MSR	-.3922	.3416	-1.3772	-.0820
	HUS to MSR	-.3347	.3120	-1.2277	-.0455
	LSR to MSR	-.4071	.3440	-1.4060	-.0962
-2.67 (50th %tile)	MSR to MSR	-.3455	.2948	-1.2184	-.0817
	HUS to MSR	-.2776	.2562	-1.0220	-.0487
56.33 (84th %tile)		Non-Significant			

Note: LSR = Low Sexual Risk; MSR = Medium Sexual Risk; HUS = High Unprotected Sex; Low Sexual Risk to Low Sexual Risk class is reference category for each time point; 95% CI = 95% Confidence Interval

Table 8. *Indirect Effect of Different Levels of Moderator on Mediation of Relationship Dependencies on Association Between Sexual Risk Behavior Latent Status from Time 3 to Time 4 on HIV/STI Incident*

Variable	Transition Status	Time 3 to Time 4 Paths			
		Indirect Effect	Standard Error	95% CI Lower	95% CI Upper
Average change in number of people diagnosed with AIDS					
-240.67 (16th %tile)	MSR to MSR	-.2718	.2781	-1.1094	-.0291
-15.67 (50th %tile)	MSR to MSR	-.2462	.2356	-.9019	-.0274
126.33 (84th %tile)		Non-Significant			
Average change in the number of people diagnoses with Syphilis					
Increase	MSR to MSR	-.6229	.3067	-1.4739	-.2667
Decrease	HUS to MSR	-.5246	.3679	-1.5237	-.1191
Average change in number of people diagnosed with Chancroid					
-1 (16th %tile)		Non-Significant			
0 (50th %tile)	MSR to MSR	-.2640	.2112	-.8333	-.0424
	HUS to MSR	-.1835	.1762	-.6790	-.0123
.33 (84th %tile)	MSR to MSR	-.2732	.2395	-.9237	-.0137
	HUS to MSR	-.2450	.2402	-.9149	-.0082
Average change in the percent of people living below the poverty level					
-6.7% (16th %tile)	MSR to MSR	-.5493	.3823	-1.6277	-.1300
3.3% (50th %tile)	MSR to MSR	-.3373	.2483	-1.0515	-.0776
	HUS to MSR	-.1832	.1801	-.6826	-.0023
16.7% (84th %tile)		Non-Significant			
Average change in the number of inmates held in jail					
Increase	LSR to HUS	-1.3635	1.0393	-4.5035	-.3807
Decrease		Non-Significant			
Average change in the number of inmates held in prisons					
-758.67 (16th %tile)		Non-Significant			

-92.67 (50th %tile)	MSR to MSR	-.2662	.2180	-.8617	-.0362
	HUS to MSR	-.1834	.1850	-.6945	-.0089
1347.67 (84th %tile)			Non-Significant		
Laws providing public funding from access to Family Planning Services and contraceptives					
Presence	MSR to LSR	.1507	.1987	-.0108	.7050
Absence	MSR to LSR	-.0956	.1600	-.5350	.0248

Note: LSR = Low Sexual Risk; MSR = Medium Sexual Risk; HUS = High Unprotected Sex; Low Sexual Risk to Low Sexual Risk class is reference category for each time point; 95% CI = 95% Confidence Interval