Distribution Agreement

In presenting this thesis or dissertation as a partial fulfillment of the requirements for an advanced degree from Emory University, I hereby grant to Emory University and its agents the non-exclusive license to archive, make accessible, and display my thesis or dissertation in whole or in part in all forms of media, now or hereafter known, including display on the world wide web. I understand that I may select some access restrictions as part of the online submission of this thesis or dissertation. I retain all ownership rights to the copyright of the thesis or dissertation. I also retain the right to use in future works (such as articles or books) all or part of this thesis or dissertation.

Signature:

_____ _____

Min Kim Date

Identifying Factors Related to HIV Infection and Transmission Risk among Young, Black Men who have Sex with Men

By

Min Kim
Doctor of Philosophy
Epidemiology

_____
Patrick S. Sullivan DVM, PhD
Advisor

_____
Michael Kramer, PhD, MMSc
Committee Member

_____
Eli Rosenberg, PhD
Committee Member

_____
Travis Sanchez, DVM, MPH
Committee Member

_____
Aaron Siegler, PhD, MHS
Committee Member

Accepted:

_____
Lisa A. Tedesco, Ph.D.
Dean of the James T. Laney School of Graduate Studies

_____
Date

Identifying Factors Related to HIV Infection and Transmission Risk among Young, Black Men who have Sex with Men

By

Min Kim
MPH, Yale University, 2007
BA, Occidental College, 2003

Advisor: Patrick S. Sullivan DVM, PhD

An abstract of
A dissertation submitted to the Faculty of the
James T. Laney School of Graduate Studies of Emory University
in partial fulfillment of the requirements for the degree of
Doctor of Philosophy
in Epidemiology
2018

Abstract

Identifying Factors Related to HIV Infection and Transmission Risk among Young, Black Men who have Sex with Men

By Min Kim

In the United States, young, Black men who have sex with men (YBMSM) are disproportionately impacted by HIV. In 2015, YBMSM accounted for more HIV diagnoses than any other race, gender, or age subgroup. Once diagnosed, YBMSM are more likely to experience negative health outcomes, including low rates of linkage to care, retention in care, and viral suppression. This dissertation seeks to identify multi-level factors facilitating HIV infection and transmission risk among HIV-negative and HIV-positive YBMSM.

In **Aim 1**, I utilized latent class analysis to construct a measure of perceived HIV risk in a sample of young, HIV-negative Black and White MSM residing in Atlanta, GA. The 4-class latent model provided both clear definitions of each class, and yielded the best statistical fit. This latent measure of perceived risk was validated against 11 sexual and non-sexual measures, providing evidence supporting two perceived risk typologies.

In **Aim 2**, I used the same sample of young MSM in Aim 1 to examine the associations between the latent typologies of perceived risk and both past and future sexual behaviors. Participants with a low risk perception were less likely to report sex with HIV status unknown partners at baseline, and were less likely to report condomless anal intercourse (CAI) at follow-up. Participants whose perceived risk was largely dependent on their partner's HIV status were less likely to report sex with HIV-positive partners at baseline, and were less likely to report CAI with HIV-positive partners at follow-up.

In **Aim 3**, qualitative timeline interviews were used to identify individual-level, dyadic, and structural factors related to antiretroviral therapy access and adherence among a sample of seropositive YBMSM engaged in HIV care in Atlanta, GA. A high proportion of YBMSM experienced secondary drug resistance and health care coverage losses during the timeline period. HIV-related stigma was a central theme that impacted YBMSM's treatment access and adherence through multiple pathways involving other multi-level domains of influence.

Findings from this dissertation can be used to inform the development of multi-level HIV prevention interventions that decrease the susceptibility among uninfected YBMSM, and reduce the transmissibility of YBMSM living with HIV/AIDS.

Identifying Factors Related to HIV Infection and Transmission Risk among Young, Black Men who have Sex with Men

By

Min Kim
MPH, Yale University, 2007
BA, Occidental College, 2003

Advisor: Patrick S. Sullivan DVM, PhD

A dissertation submitted to the Faculty of the
James T. Laney School of Graduate Studies of Emory University
in partial fulfillment of the requirements for the degree of
Doctor of Philosophy
in Epidemiology
2018

ACKNOWLEDGEMENTS

First, I'd like to thank each and every one of my committee members for their patience, guidance, and support throughout my time here at Emory University. To Michael Kramer, thank-you for your guidance. I learned a great deal from you, both in the classroom and in our meetings together. To Eli Rosenberg, thank-you for your expertise. You were always able to explain complicated methods in a way that was easy to comprehend. To Travis Sanchez, thank-you for your insight. Your thoughtful questions helped me look at things from a different perspective. To Aaron Siegler, thank-you for taking the time to teach me about qualitative methods, something that was previously foreign to me. Your positive attitude and encouragement were uplifting. To Patrick Sullivan, thank-you for your support. During the times when I didn't think that I'd be able to finish, you always instilled within me a great sense of confidence in my own abilities. Even though this process was long and arduous, filled with many ups and downs, thank-you for believing in me.

To my parents, Nan and Yoong, and sister Jin, thank-you for all the love and support you've provided all these years. You've sacrificed so much so that I'd have the opportunities to follow my passions and pursue my dreams.

And to my partner Heejoo. Thank-you for your unconditional love, support, and selflessness. I wouldn't have been able to finish my studies without your patience and encouragement. Thank-you for lifting my spirits when I was down, and for always being by my side.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1. BACKGROUND AND SIGNIFICANCE

Epidemiology of HIV among MSM in the U.S.

Men who have sex with men (MSM) continue to be disproportionately impacted by the HIV epidemic in the United States. In 2014, MSM represented only 2% of U.S. population, yet accounted for 70% of incident HIV infections.[1] In 2015, MSM accounted for 82% of new HIV diagnoses among males, and 67% of all new diagnoses.[1] Although the number of incident infections have recently stabilized, male-to-male sexual contact was the only mode of transmission in which the proportion of new HIV diagnoses increased from 2010-2015.[2]

African-Americans continue to bear the greatest burden of HIV in the United States, moreso than any other race. In 2016, African-Americans made up 12% of the U.S. population, yet comprised 44% of all new HIV diagnoses.[3] Compared to other gender, race, and transmission risk category subpopulations, Black MSM had the highest number of new HIV diagnoses in 2016.[3]

Racial disparities in HIV are also evident among young MSM (YMSM). HIV incidence increased 34% among YMSM and 48% among young Black MSM (YBMSM) from 2006 to 2009.[4] From 2008 to 2011, YMSM aged 13-24 experienced the greatest percentage increase in diagnosed HIV infections (compared to other age groups), and YBMSM experienced the largest increase in new diagnoses (compared to other races).[5] These trends have persisted in 2016, with African-Americans accounting for the largest number of HIV diagnoses among MSM aged 13-34.[6] From 2011-2016, the rate of HIV diagnoses among Black adolescents was five times the rate for Hispanic/Latino adolescents, and 19 times the rate of White adolescents.[7]

Transitioning the HIV Prevention Agenda in the U.S.

In the past, HIV prevention initiatives have targeted those without infection, but starting in the early 2000s, the CDC expanded the focus of HIV prevention efforts to include the HIV-positive population.[19,86] Because transmission can only occur from those already infected, focusing prevention efforts on seropositive individuals, which represents a small population compared to the entire population at risk, can be a more efficient prevention strategy.[19]

Alongside health benefits to person living with HIV/AIDS (PLWHA), antiretroviral therapy (ART) has been shown to prevent vertical transmission from mother to child.[87] This provided the proof of concept to the idea that therapy can be utilized as a mechanism to prevent the sexual transmission of HIV. Multiple studies, including the landmark results of HPTN 052, found that the early provision of ART and subsequent suppression of viral load levels significantly decreased HIV transmission rates.[88-93] Mathematical simulations have demonstrated that universal testing and treatment can reduce HIV incidence by 60% in three years and reduce prevalence levels to less than 1% in 50 years.[94,95] In 2016, the Undetectable = Untransmissible (U=U) campaign was launched by the Prevention Access Campaign to promote findings from multiple studies showing that sexual transmission of HIV cannot occur when a seropositive individual is virally suppressed.[112] Three prospective studies (two observational cohort studies and one randomized controlled trial) followed almost 3,000 serodiscordant heterosexual and homosexual couples and found zero transmissions linked to an HIV-positive partner who was virally suppressed.[44,88,113] The concept of treating PLWHA as a means to prevent infection has gained traction, bringing about a fundamental shift in the HIV prevention agenda.

HIV Continuum of Care

In 2010, the White House released the National HIV/AIDS strategy whose goals are to reduce new HIV infections, increase access to care and improve health outcomes for PLWHA, and reduce HIV-related health disparities.[96] The HIV care continuum (also known as the HIV treatment cascade) was included in this strategy as a model to assess and improve HIV testing strategies, and the delivery and quality of HIV care services, including access to HIV treatment.[97] The HIV treatment cascade consists of five sequential indicators: 1) HIV diagnosis, 2) linkage to care, 3) retention in care, 4) initiation of antiretroviral therapy, and 5) viral load suppression (Figure 1.1).[98,99]

Figure 1.1. HIV Continuum of Care [100]

U.S. Department of Health and Human Services, HIV.gov

The HIV treatment cascade describes a spectrum of patient care that is dynamic, bi-directional, continuous, and occurs over the entire lifespan of HIV-positive individuals from the time they are diagnosed.[99,101] On occasion, patients who are fully engaged in care may go on to drop out of care for periods of time, or patients who were once virally suppressed may experience stretches of rebound.[101-103] These events require patients to re-enter the treatment cascade at different points in the continuum so that they can continue to navigate their way towards viral suppression.

Racial Disparities in the HIV Continuum of Care

By the end of 2010, approximately 16% of PLWHA in the U.S. were undiagnosed, and among those diagnosed, 80% were linked to care, 51% were retained in care, and 39% had a suppressed viral load.[104] In 2015, 14% of PLWHA in the U.S. were undiagnosed, 63% were receiving care, 49% were retained in care, and 51% were virally suppressed.[105] While improvements in treatment cascade indicators are evident, racial disparities in the HIV continuum remain.[97] The percentage of Black HIV-positive individuals at each step of the continuum were lower compared to White PLWHA, especially among MSM.[15,104-106] From 2008-2015, Black MSM were more likely to be unaware of their HIV infection compared to White MSM.[107-109]

Age disparities in continuum of care outcomes are also evident among PLWHA and corresponding MSM subpopulations, with younger age groups at higher risk for treatment cascade failures (e.g., undiagnosed infection, late/no linkage to HIV care, inconsistent HIV care, late or no initiation of antiretroviral therapy, unsuppressed viral load levels).[104,107-111] In 2008, the highest proportions of MSM unaware of their infection were found in the youngest age groups, with Black MSM having twice the level of undiagnosed infection compared to White MSM, aged 25-29.[107]

Effectiveness of Behavioral Interventions on Reducing HIV Incidence

Historically, HIV prevention efforts in the U.S. have targeted reducing individual-level risk behaviors among those without disease.[19-21] The Centers for Disease Control and Prevention (CDC) publishes and regularly updates a list of effective evidence-based HIV prevention interventions (EBIs) organized into four chapters: risk reduction interventions, linkage, retention, and re-engagement in HIV care interventions, medication adherence interventions, and structural

interventions.[22] The majority (61 out of 97) of interventions listed in this compendium seek to change sexual or drug-injection behaviors tied to HIV transmission risk, pointing to the prior emphasis placed on behavioral risk reduction as a primary prevention strategy.[22,23] Although behavioral interventions are effective in reducing rates of risk behaviors (e.g., condomless anal intercourse, number of sex partners, sharing of drug injection paraphernalia) within a variety of high risk populations, there has been no evidence to suggest these interventions can reduce HIV incidence.[24-32] Additionally, the initial reduction of risk behaviors following implementation of behavioral interventions typically wane over time, limiting their long term effects.[31,33,34]

Multi-Level Risk Factors as an Explanation for Racial Disparities in HIV

Risk-reduction interventions targeting MSM aim to reduce levels of condomless anal intercourse (CAI), since that is believed to be the primary mode of HIV transmission for this population.[8,9] Racial differences in the rates of CAI (among other risk behaviors) have been hypothesized as a primary driver of Black-White disparities in HIV infection.[9] However, numerous studies have found that Black MSM have similar or lower levels of reported risk behaviors compared to White MSM.[8,10-14]

Studies attempting to explain the burden of infection experienced by Black MSM have moved away from examining individuals' behavior in isolation, and have instead looked to evaluate dyadic factors describing their partners, and structural factors describing their sexual networks, and the environment or community with which they interact.[10,15,16] Some of the factors hypothesized to contribute to this disparity include sex partner-level discordance (or concordance) in age, race, and HIV serostatus, concurrency of sex partnerships, and community-level differences in poverty, unemployment rates, or income levels.[10,15-18] One study found that differential rates in sex partner selection by race could not sustain racial disparities in HIV

prevalence between Black and White MSM.[17] In another study, Black MSM were more likely to engage in condomless anal intercourse (CAI) with concurrent partners (those that overlapped with one another) compared to White MSM, placing them at greater risk for potential exposure to HIV.[18]

Potential Reach of Multi-Level HIV Prevention Strategies

Behavioral interventions are usually limited in terms of reach.[37] For example, educational interventions that promote condom use are only effective for small segments of the population who receive the intervention and adhere to its protocol.[36] However, decisions on using condoms are often made within dyads (partnerships) depending on characteristics of the partner, including their HIV status, the type of relationship (e.g., primary vs. casual), and sexual preferences (e.g., receptive vs. insertive anal intercourse).[172-175,291] Even dyadic-level interventions such as couples HIV counseling and testing will have limited coverage, only impacting the individual and his partner.

Significant population-level changes in HIV transmission require large numbers of people to change their behaviors, and maintain these changes for a sustained period of time.[39] Structural interventions seek to change the environment in which individuals engage in health-related behaviors, and address the underlying structures affecting individual risk and vulnerability to HIV.[45,46] These interventions have the potential of reaching the largest number of people, and often involve changes to policy that encourages the practice of safe behaviors.[45] For example, in 1989, the Thai government bought and distributed a sufficient amount of condoms to commercial sex venues, and passed laws requiring the use of condoms in brothels.[47] Over a four year period, condom use among sex workers increased 80%.[47] At the local level, structural improvements in access to care and standards in care may affect large groups of people, and have

a longer-lasting impact than individual or dyadic-level interventions.[45] Two structural interventions introduced youth-specific services (e.g., youth clinic, adolescent care providers, youth-focused social workers and case manager, etc.) in regions where none had previously existed.[114,115] Studies found that retention in HIV care among HIV-positive Black youth improved after incorporating a youth program within the HIV clinic.[114,115]

Proximal vs. Distal HIV Risk

Individual-level interventions often target immediate or proximal risks to HIV infection.[37] These proximal risks are often behavioral or biologic factors that directly affect the likelihood of infection or transmission of HIV.[292] Interventions that minimize proximal risks of infection often make changes to mechanisms by which HIV enters the body of an uninfected individual (i.e., mode of transmission), or directly changes the biology of the virus or the host itself. For instance, interventions that promote increases in condom use will minimize one's potential exposure to HIV (behavioral), while the condom itself will block the virus from infecting susceptible cells (biomedical). An example of biologic factor is HIV viral load, which largely determines the transmissibility of the virus.[89] Effective biomedical interventions that prevent viral replication (i.e., suppress viral load) include the provision of antiretroviral therapy to seropositive individuals (HIV treatment as prevention – TaSP).[44]

Proximal factors related to HIV infection represent one of many mechanisms through which more fundamental causes operate, and in the long term, will do little to eliminate disease unless the underlying structures governing these risks are addressed.[50] Distal determinants of HIV risk affect the environments and structures within which proximal factors (e.g., behavioral, biologic) reside. Some examples of distal factors at the community-level may include poverty, socio-cultural norms and values, HIV-related stigma or discrimination, and accessibility

to health care services.[292] For instance, high levels of HIV-related stigma within the community (distal) can make it harder for PLWHA to access and adhere (proximal) to critical biomedical therapies (e.g., antiretroviral therapy).[200,201] On a larger geographic scale, structural factors such as state or national policies provide the general framework for shaping the risk of all members of a society, particularly marginalized groups.[292] Structural interventions that address these core (distal) facilitators of HIV risk can maximize the accessibility and impact of both behavioral and biomedical interventions.[39,50] The figure below (Figure 1.2) provides a list of proximal and distal determinants of HIV risk and corresponding interventions.[293]

Figure 1.2. Proximal vs. Distal Determinants of HIV Risk [293]

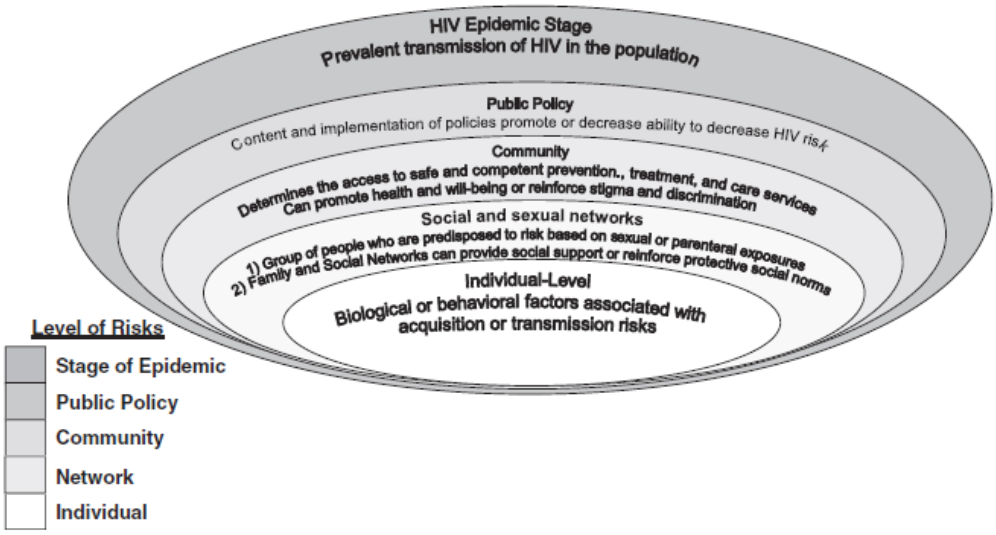
Determinants	**Distal determinant → Proximal determinants**			
	Macro-environment	**Micro-environment**	**Behaviour**	**Biology**
	Wealth or poverty	Mobility	Rate of partner change	Age
	Income distribution	Urbanisation Education	Prevalence of concurrent partners	Stage of infection and Virus sub-types
	Culture	Access to health care	Sexual mixing patterns	Presence of other STIs
	Religion	Levels of violence	Sexual practices and condom use	Gender
	Governance	Women's rights and status	Age of sexual debut	
			Levels of sexual & physical abuse	Circumcision
Interventions	Social policy redistribution Legal Reform Human Rights Taxation Debt relief Terms of Trade	Social Policy Economic Policy Legal Reform Employment Legislation	Behaviour change communication including: Condom use Delay sexual debut Fewer partners Address abuse and violence	STI treatment Condom Promotion Anti-retroviral therapy during pregnancy Blood safety Post exposure prophylaxis

Socio-Ecologic Model and Combination HIV Prevention

Social ecological models help explain the complex associations between individual, social, structural, and environmental factors and how they affect health.[292] These models

describe the interactions at multiple levels of intrapersonal (e.g, knowledge, attitudes), interpersonal (e.g., social network, social support), community (e.g., stigma, access to health care), and political (e.g., local, state, national laws) factors, and how they influence individuals' behaviors (Figure 1.3).[292] The socio-ecologic model is based on the premise that while individual-level risks are necessary for the spread of HIV, they are insufficient in explaining population-level transmissions.[292]

Figure 1.3. Socio-Ecologic Model of HIV Risk [292]

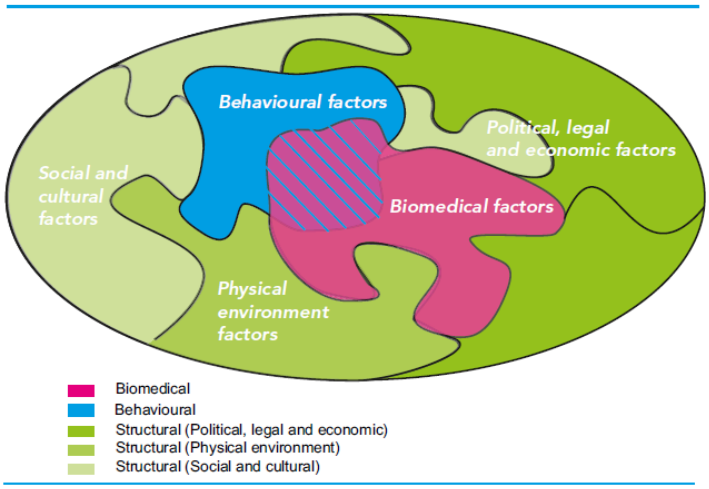


No single HIV prevention intervention alone, even if an effective vaccine were available, is likely to have a significant impact on ending the HIV epidemic.[35] Given the limitations of individual-level behavioral interventions in reducing HIV incidence, researchers have been advocating for packaging interventions addressing HIV risk at multiple levels (e.g., individual, relationship, community, societal).[35,37-39] As such, experts have been advocating for combination

HIV prevention strategies, which are composed of a mix of complementary behavioral, biomedical, and structural interventions operating at multiple levels (Figure 1.4).[35,37-39] Combining interventions that impede different areas of the HIV transmission cycle may also have synergistic effects in reducing HIV incidence, more than the effect these interventions may have had if implemented separately.[35-39]

Figure 1.4. Combination HIV Prevention

© Joint United Nations Programme on HIV/AIDS (UNAIDS) 2010. [37]



Lack of Multi-Level HIV Prevention Interventions Targeting YBMSM

Progress in incorporating structural approaches to HIV prevention efforts has been limited.[46,50] For one, these interventions target deeply entrenched social, political, and economic structures that are difficult to change and commonly viewed as long-term initiatives not necessarily within the purview of HIV prevention efforts.[46,50] Additionally, structural interventions are difficult to evaluate methodologically.[46,50] These interventions can involve entire populations, making randomization impossible, and implementation is usually out of the control of researchers.[50] Natural experiments, which are more prone to bias (e.g., confounding), are often used to evaluate the impact of these interventions.[50,51]

Since structural interventions were ultimately designed to reduce rates of HIV transmission, inclusion of long-term outcomes such as HIV incidence are necessary. Reliable measures of HIV incidence may be difficult to obtain, and even if available, attributing reductions in infections to the intervention may be challenging if: 1) there are other prevention programs implemented during the same timeframe or among similar populations, 2) the general trajectory of HIV transmissions within that group was already declining, or 3) these interventions include components (e.g., social/political mobilization) that result in a variety of dynamic activities outside of the intervention itself.[35,37,46,50] The large sample sizes (structural interventions affect large groups of people) and lengthy study durations (long term outcomes require following people over extended periods of time) needed for structural intervention studies further restrict their development, implementation, and evaluation.[35] The CDC lists a total of only eight structural EBIs, two of which were designed to improve retention in HIV care among HIV-positive Black youth.[52,114,115]

Although combination prevention is not a new idea and is widely endorsed, it is rarely implemented.[37] In fact, no major multicomponent package of multi-level interventions has been launched in a full scale, community-level randomized trial to assess its impact on HIV incidence.[35] Many examples of sustained public health success has depended on the strategic combination of biomedical, behavioral, and structural prevention strategies to address individual-level risks and to create a more enabling environment for health.[37] In the 1990s, Uganda implemented a variety of behavioral (reduction in number of casual sex partners and increase in condom use with casual partners), biomedical (increased availability of condoms), and structural (empowering women and youth, destigmatizing HIV in the community) interventions that paralleled vast declines in HIV prevalence and incidence.[37,53,54]

Relationship between HIV Risk Perception and Sexual Behaviors

HIV risk perception, which is defined as an individual's perceived susceptibility to HIV infection, is a fundamental component to numerous theoretical models of health behavior, including the Health Belief Model, Social Cognitive Theory, Theory of Reasoned Action, Theory of Planned Behavior, Protection Motivation Theory, Extended Parallel Process Model, and the AIDS Risk Reduction Model.[124-130,294] These theories posit that the likelihood of becoming infected with HIV (perceived HIV risk) can help shape and influence health behaviors.[295] Two meta-analyses found strong evidence supporting the relationship between perceived risk and a variety of health behaviors including vaccination, smoking, exercise, and sexual behaviors.[295,296] These studies suggest that changing perceptions of risk may lead to improvements in health behaviors.[294]

After the introduction of highly active antiretroviral therapy (HAART), mortality rates for PLWHA were cut by more than half from 1993 to 2002, and the life expectancy for 20 yr. olds increased 24 yrs. from 1993 to 2011.[62,63] With these vast improvements in health, experts hypothesized that both HIV-negative and HIV-positive individuals would be less concerned about acquiring or transmitting HIV/AIDS.[64-66] In the years following the advent of effective combination therapies, increases in the incidence of sexual behaviors and sexually transmitted infections were found among MSM.[66-75] The use of ART among seronegative individuals to prevent HIV infection (pre-exposure prophylaxis - PrEP) may have also decreased their perceived risk of HIV. A recent meta-analysis among MSM found that PrEP users were 25 times more likely to acquire *N. gonorrhea*, 11 times more likely to acquire *C. trachomatis*, and 45 times more likely to acquire a syphilis infection compared to non-PrEP users.[171]

Results for studies evaluating the relationship between HIV risk perception and sexual behaviors have been inconsistent. Some studies have found increases in condom use associated with higher levels of risk perception (i.e., belief that there is a high chance or likelihood of becoming infected or transmitting HIV), while others have found the opposite.[76-79] The poor measurement of perceived HIV risk, frequent use of cross-sectional study designs, and inadequate control of important multi-level factors may have contributed to the lack of reliable findings.[80,81]

Behavioral prevention strategies alone are insufficient in reducing HIV incidence at the population-level, but remain essential components of a comprehensive HIV prevention strategy since they target the very behaviors that are responsible for a majority of HIV transmissions at the individual-level.[39,292] However, interventions that are designed to solely affect behaviors of the individual without incorporating aspects of an individual's relationship with others (dyadic), and characteristics of the broader community of which they are a part of, may be ineffective. Perceived risk can vary from one partner to the next (and even within the same partner over time) depending on various partner characteristics (e.g., partner HIV status, main vs. casual partner).[79,80,132,146-148] For example, one's perceived risk of HIV infection may be higher for a sex partner who is HIV-positive vs. HIV-negative. These factors can also influence the types of behaviors individuals are willing to engage in with these partners. Risky behaviors have been found to be more prevalent in main vs. casual partnerships.[172-174] Another study found that rates of CAI were higher among seroconcordant (both HIV-positive and HIV-negative) vs. serodiscordant couples.[175]

Interventions that elevate one's perception of HIV risk may not decrease the practice of high-risk sexual activities if dyadic-level factors are not accounted for. Studies that ignore

partner-level (dyadic) factors that serve as potential confounders or moderators will likely result in biased effect estimates of the relationship between perceived risk and sexual behaviors.[134] Few studies have adequately controlled for important multi-level factors including partner type and partner HIV status.[81]

Lack of Multi-Level Interventions that Improve ART Adherence among YBMSM

HIV viral load suppression is crucial for both the health of HIV-infected individuals, and for the health of their sex partners. Without proper adherence to ART, viral load levels will remain high enough to facilitate disease transmission at all stages of HIV infection.[76,77] Multi-level prevention strategies that improve HIV medication adherence among PLWHA are lacking. Individual-level behavioral interventions commonly include educational components that inform HIV-positive individuals about the direct (e.g., improved survival) and indirect (e.g., minimizes transmission to others) benefits of adhering to their HIV medications. Based on their responses to a risk assessment, participants in one study were administered a tailored computer-counseling (individual-level) intervention that was designed to improve skills around HIV disclosure, safer sex, ART adherence, substance abuse, and condom use.[297] After a 9 month follow-up period, adherence levels in the intervention arm were higher compared to the control arm.[297] Dyadic interventions may also involve educating the individual and their partners about the importance of ART adherence, along with collaborative sessions to identify barriers to adherence, and develop strategies to overcome these barriers. In another study, serodiscordant couples were randomized to an (dyadic) intervention that educated them about the importance of adherence in order to avoid viral resistance and maintain health, identified patterns of non-adherence, developed communication and problem-solving strategies to overcome adherence barriers, and optimized partner support and confidence in maintaining high levels of adherence.[298] Although

immediate improvements in adherence was found in the intervention arm, differences in adherence levels diminished over time.[298]

Once diagnosed with HIV, PLWHA must successfully navigate their way through the treatment cascade in order to achieve viral suppression. This necessitates that they interact with various health care systems, programs, and funding sources so that they can obtain access to HIV care services and ART. Inherently, structural and environmental factors outside of their own control, play a larger role in the HIV-positive individuals' access and adherence to ART. For example, the availability of affordable health insurance can impact PLWHA's access to medications.

Because YBMSM are at high risk of transmitting HIV to others, it is important to develop interventions that improve their movement through the HIV continuum of care. As mentioned before, only a few structural interventions facilitated PLWHA's navigation through the treatment cascade, and even fewer were found to be efficacious among YBMSM. Project nGage was a randomized controlled trial that elicited existing social support network members of YBMSM.[117] The dyadic intervention educated both HIV-positive YBMSM and their network members on the importance of engaging in HIV care and adhering to their medications, and also included a collaborative session to identify and problem-solve potential barriers to retention in care and ART adherence.[117] This is one of the few interventions that improved rates of retention and medication adherence among YBMSM.[117] To our knowledge, there are no structural interventions designed to improve HIV medication adherence among YBMSM.[116]

Further exploration is needed to identify multi-level factors associated with ART access and adherence among YBMSM. A few studies have identified individual-level factors (socio-demographic characteristics, risk behaviors, psychosocial factors) related to various treatment

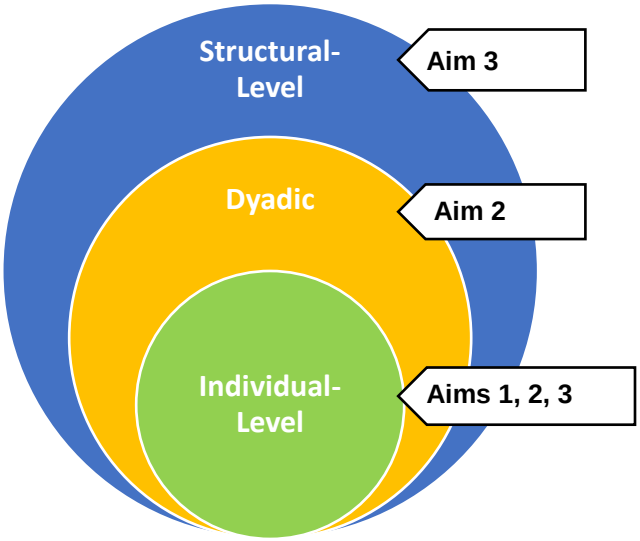
cascade outcomes (linkage, engagement, retention in care, access and adherence to ART) among HIV-positive YBMSM.[118-121] In one study, psychosocial factors such as negative self-image (a component of stigma) and a lack of ethnic identity were associated with delayed linkage to care, poor retention in care, and limited access to ART among YBMSM.[118] No factors were associated with HIV medication adherence in this study.[118] In another study by Hightow-Weidman et al., a combination of factors: communication self-efficacy with one's health care provider, health insurance, higher education, and limited/no illicit drug use was associated with engagement and retention in care, and ART uptake among YBMSM.[119] In this study, participants who disclosed their HIV status to others were more likely to adhere to their treatment regimens.[119] The identification of individual-level, dyadic, and structural factors associated with ART access and adherence can be used to inform the development of effective combination prevention strategies targeting YBMSM.

Purpose of the Dissertation

The purpose of this dissertation is to identify multi-level factors associated with HIV infection and transmission risk among YBMSM. The scope of all three dissertation aims reflect the goals of a comprehensive HIV prevention strategy that seek to reduce susceptibility to HIV in the uninfected, and reduce the transmissibility of the virus among those infected. Although each dissertation aim does not directly measure HIV incidence/transmission, important correlates related to, but distal to actual HIV acquisition/transmission are used. In Aim 1, I developed a measure of HIV risk perception using questions conditional on partner (dyadic) characteristics. In Aim 2, I evaluated the relationship between HIV risk perception and sexual behaviors (related to HIV infection risk) at the partnership (dyadic) level within a seronegative population, and how this association may differ by individual-level and dyadic factors. In Aim 3, I identified themes

related to ART access and adherence at the individual, dyadic, and structural levels within a seropositive population (Figure 1.5). This dissertation will address important gaps in the literature that will help inform the development of effective multi-level interventions targeting YBMSM.

Figure 1.5. Multi-Level Framework of Dissertation Aims



Dissertation Aims

In Aim 1, I developed a novel measure of HIV risk perception through latent class analysis (LCA), using data collected from White and Black HIV-negative MSM residing in Atlanta, GA. The different typologies of perceived risk were validated against previously reported sexual behaviors and other non-sexual measures.

In Aim 2, I evaluated the relationship between prior sexual behaviors and perceived HIV risk, and the relationship between HIV risk perception and future behaviors using the latent measure developed in Aim 1. Specifically, I assessed whether the association between perceived risk and future behaviors differed by race, partner type, and partner HIV status.

In Aim 3, I identified themes related to access and adherence to ART among HIV-positive YBMSM receiving HIV care in Atlanta GA. A mixed-methods approach, including a

semi-structured timeline interview was used to explore relevant experiences for four types of viral suppression categories: those who remained 1) virally suppressed, 2) virally unsuppressed, 3) gained viral suppression, and 4) lost viral suppression.

CHAPTER 2. EVALUATING THE CONSTRUCT VALIDITY OF A LATENT MEASURE OF HIV RISK PERCEPTION AMONG YOUNG, HIV-NEGATIVE MSM IN ATLANTA, GA

INTRODUCTION

Theoretical Relationship between HIV Risk Perception and Sexual Behaviors

Theoretically, there are dual mechanisms of action that involve HIV risk perception and sexual behaviors. In one, perceived HIV risk reflects the past risk, and in another, perceived HIV risk affects future behavior. For example, engaging in risky sexual behaviors in the recent past may result in elevated perceptions of HIV infection risk, which can subsequently motivate individuals to avoid these behaviors in the future.[132-134]

Previous Literature on the Association between Perceived HIV Risk and Sexual Behaviors

Although it's plausible that an individual's perception of their own HIV (infection or transmission) risk may be just as influential in predicting sexual behaviors as any biomedical therapy (antiretroviral therapy use, pre-exposure prophylaxis), biological marker (viral load levels), or behavior (HIV status disclosure), findings from previous studies evaluating this relationship have been inconsistent.[132,133] HIV-positive individuals who believed they were at low risk for transmitting HIV, and those (regardless of HIV status) who had a reduced level of concern about HIV were more likely to engage in CAI in numerous studies.[65,78,122,135-139] This association remained even after controlling for important confounders such as ART use and/or HIV viral load levels.[74,140-142] Other studies found no association between perceived risk (or HIV treatment optimism) and sexual behaviors among both seropositive and seronegative MSM.[123,143,144]

Issues in the Measurement of HIV Risk Perception

Researchers have suggested that inconsistencies with the measurement of HIV risk perception may have contributed to discrepant study findings.[80,133] Past studies evaluating the relationship between perceived risk and sexual behaviors have often used an ambiguous and non-specific question to assess risk perception.[145] A single question in the form of: "What are your chances of getting infected with HIV, the virus that causes AIDS?" was commonly used to measure perceived risk.[133-135,138] A single question may be inadequate in capturing the complex manner by which people feel and think about their risk of HIV infection, and insufficient in addressing the multiple dimensions that comprise the perceived risk construct.[131,134,135] A single question also limits the ability to differentiate those at the lower and higher end of the perceived risk spectrum. [80,134,139] Studies that recruited participants from low-risk populations have found that a significant proportion of their sample believe they are at little to no risk of HIV infection.[80,134,139] Consequently, the range and variance of the measure becomes limited, and data are not sufficient enough to detect subtle changes in the perceived risk construct.[80,134,139]

Authors have advocated for adopting questions that tie the likelihood of HIV infection to scenarios involving specific behaviors (condom use, sexual position) and/or partner characteristics (HIV status, partner type, antiretroviral therapy use, viral load levels) to minimize any ambiguity.[78-80,131,133,139,146-149] Levels of perceived risk can vary by demographic factors (age, gender, race, education, employment), risk behaviors (condom use, illicit drug use, history of sexually transmitted infections, number of sex partners, sexual positions), HIV testing frequency, and partner characteristics (age, HIV status, partner type).[76,77,79,80,131,133,138,146-148,150-153] Yet, a majority of studies have used questions that do not incorporate these factors into their measures of risk perception.[133,138,144,145]

Study Purpose, Aims, and Hypotheses

Study Purpose

The purpose of this study is to develop and validate a novel conceptualization of perceived HIV risk through latent class analysis (LCA), using data on risk perception collected from HIV-negative Black and non-Hispanic White MSM residing in Atlanta, GA.

Study Aims

1. Latent class analysis was used to create a unique categorization of perceived risk using a series of 16 questions conditional on specific sexual behaviors (condom use, sexual position) and partner characteristics (HIV-status, antiretroviral therapy use/viral load status).
2. Construct validity of each of the latent perceived risk typologies were validated against reports of past sexual behaviors (e.g., CAI) and other non-sexual correlates (e.g., HIV knowledge).

Study Hypotheses

In this study, questions conditional on sexual behaviors and partner characteristics were used to construct the latent measure of HIV risk perception. Although the number and characterizations of latent classes cannot be predicted *a priori*, we expect the classes to reflect different patterns of behavior. In other words, these classes should indicate specific combinations of partner types and behaviors that participants feel place them at high risk for HIV infection. For example, the latent model may produce a class of participants who believe that sex with an HIV-positive partner is high risk regardless of condom use, sexual position, or the partner's viral load suppression status.

Prior studies used an ordinal (high/low) categorization of perceived risk. These studies hypothesized that those who reported high levels of past risk behaviors would also report higher levels of perceived risk. Based on the number of domains (3: partner HIV status, condom use, sexual position) that were used to differentiate the inputs for the latent model, we expect to produce at least three different classes of risk perception. Even if a 2-class latent model were selected as the best fitting model, these classes would likely differ from the typical high/low categorization used in prior studies, since LCA creates classes not strictly based on numeric scales, but identifies patterns of responses from the conditional inputs.

To assess the construct validity of the latent perceived risk measure, we validated the different latent typologies against actual reports of past sexual behaviors and other non-sexual correlates related to HIV risk. We expect the latent perceived risk measure to have stronger associations with past sexual behaviors compared to other, non-sexual correlates, since the inputs used to construct the measure were conditional on sexual behaviors. For instance, a latent class may describe participants whose perceived risk is not determined by the HIV status of their partner, but is largely influenced by condom use. These participants may rate any condom-protected sex act as low risk and any non-condom protected sex act as high risk, regardless of partner status or sexual position. We hypothesize that these participants should be less likely to engage in CAI compared to participants in other classes. The preferences and patterns of sexual behaviors that characterize the different typologies of perceived risk should correlate with actual sexual behaviors that were reported. *A priori* hypotheses for each class were formed after the determination of the “best” latent model.

METHODS

InvolveMENt Study

The data that will be used for this analysis come from the InvolveMENt study, which was a prospective cohort study conducted at Emory University. This study was designed to identify multi-level factors (individual, dyadic, and community-level) that contribute to racial disparities in HIV (and sexually transmitted infections) prevalence and incidence among Black and White, non-Hispanic MSM living in Atlanta, GA.[16]

Recruitment

Recruitment occurred over a two-year period from June 2010 to December 2012.[16] Time-space venue sampling, supplemented by convenience sampling via Facebook was utilized to recruit MSM. For venue sampling, a random sample of places MSM frequent in Atlanta was chosen based on methods used to recruit participants in the National HIV Behavioral Surveillance System (NHBS) among MSM.[154] All venues, and day-time periods (VDTs) from which an adequate number of MSM can potentially be sampled were included in the sampling frame.

Study Population & Eligibility Criteria

Eligibility criteria were assessed at both the time of recruitment and at the baseline visit. Individuals were eligible for the study if they were:

1. Male at birth,
2. Ages 18-40,
3. Self-reported Black or White race,
4. Could complete study instruments in English,
5. Currently lived in the Atlanta metropolitan statistical area,

6. Had at least one male sex partner in the past 3 months, and

Individuals were excluded if they were of Hispanic/Latino ethnicity, had plans to move out of Atlanta in the next two years, were in a mutually monogamous relationship with a man, or were involved in another HIV prevention study.[16]

Baseline Visit

At the baseline visit, participants completed an approximately 1.5 hr. computer assisted self-interview questionnaire which included the following domains: demographics, psychosocial scales, community characteristics, individual-level HIV risk behaviors, and a dyadic inventory of their 5 most recent sex partners in the last 6 months. Participants were compensated $60 for their baseline visit.

During the baseline visit, participants were screened for HIV regardless of their self-reported HIV status, using a FDA-approved rapid HIV antibody test. For those who tested preliminary positive via rapid test, a confirmatory Western blot was conducted using blood samples. HIV-negative participants at baseline were either followed over the entire two-year study period, or until they seroconverted. Participants who tested positive at baseline were not followed up and were excluded from this analysis.

Study Measures and Definitions

Measures Used to Construct Perceived HIV Risk

The InvolveMENt survey included a series of 16 risk perception questions in which participants were asked to rate how risky a hypothetical sexual encounter is on a Likert scale from 1 (completely safe) to 10 (completely risky). The 16 scenarios were differentiated by the HIV status of the sex partner (unknown status, HIV-negative, HIV-positive on antiretroviral medication with an undetectable viral load, and HIV-positive not on antiretroviral medication),

sexual position (receptive anal intercourse, insertive anal intercrouse), and condom use (protected, unprotected).

For example, one scenario might have the participant imagine he met a man of unknown HIV status with which he wants to have sex with. The survey will describe that the participant is "the insertive partner during anal intercourse without a condom" in this scenario, and prompt him to rate how risky that sex act is with regards to his *own health*. These questions come from a previous study looking at the effect that partner HIV status and partner antiretroviral therapy use has on MSM's perceptions of HIV risk.[148] See *Appendix A* for the full set of questions.

Latent Class Analysis (LCA)

Latent class analysis (LCA) is a method that uses the data to identify patterns or subgroups within a population that would otherwise be unobservable.[155] Using this methodology, a latent variable and its "classes" (or categories) are created from observed patterns in the data.[155] Instead of evaluating relationships between individual variables and assuming these relationships apply to the population at large, LCA identifies subgroups of individuals that exhibit similar patterns of characteristics in order to explain causal processes.[155] Essentially, LCA categorizes respondents based on a group of exposures, such that members of the same latent class have similar patterns of exposures. For example, the data may show there is a subgroup of participants (Group A) who reported that sex with HIV-positive or HIV status unknown partners was very risky (and conversely, sex with HIV-negative partners was completely safe) regardless of condom use, sexual position, or ART use. Another latent class (Group B) may include participants who rated unprotected sex acts as risky and protected sex acts as safe, regardless of the partner's HIV status, ART use, or sexual position. Based on their pattern of responses, we

can surmise that Group A participants value their partner's HIV status most, and Group B participants emphasize condom use when evaluating their perception of HIV risk.

The LCA model estimates the latent class membership probabilities and item-response probabilities conditional on latent class membership (i.e., probability of a specific response to an item based on the latent class assignment).[156] The statistical model measures the probability of an individual's responses to a vector of inputs as a function of the probability of membership in latent class *c* (γ_c), and the probability of response r_j to item *j*, conditional on membership in latent class *c* (ρ_j).[156] The equation below depicts the LCA statistical model.

$$P(\mathbf{Y}=\mathbf{y})=\sum_{c=1}^{K}\gamma_c\prod_{j=1}^{J}\prod_{r_j=1}^{R_j}\rho_{j,r_j|c}^{I(y_j=r_j)},$$

Once the parameters of the latent class model have been estimated, posterior probabilities of membership in each class can be estimated for each individual using Bayes' Theorem (see equation below).[156]

$$P(C=c|Y=y)=\frac{P(C=c)P(Y=y|C=c)}{P(Y=y)},$$

Responses from 16 separate questions assessing perceived risk by partner HIV status, sexual position, and condom use were used to create a latent variable representing perceived HIV infection risk. Because the underlying range of question responses represent a spectrum of risk, each of the 16 covariates were converted into categorical variables using three cutpoints (1-4 = low, 5-7 = medium, 8-10 = high) in order to distinguish low versus high extremes of risk perception. These 16 categorical variables were used as the inputs in PROC LCA to create a latent variable representing perceived HIV infection risk.[157]

Multiple factors were used to determine the ideal number of classes for the latent variable. Fit statistics for each of the LCA models yielding 2-10 classes were obtained, including: the deviance statistic (likelihood ratio G^2), Bayesian Information Criteria (BIC), Akaike's Information Criteria (AIC), adjusted BIC, and the consistent AIC (cAIC). The AIC, BIC, cAIC, and adjusted BIC are goodness of fit statistics that consist of a penalized (penalty is a function of the sample size and number of parameters in the model) log-likelihood function.[158] Model fit cannot be assessed using a traditional likelihood ratio test, since the difference in the deviance statistic between nested models does not follow a chi-square distribution.[159,160] Smaller values of goodness of fit indices may indicate better model fit.[160] We used the difference in fit statistics between nested models (e.g., comparing a 2 class model vs. a 3 class model) to objectively compare model fit. The best fitting model was chosen based on the majority of evidence from these five statistics.

Entropy statistics measure the level of separation between classes with values close to 0 indicating a low level of separation and values close to 1 indicating a high degree of differentiation.[160] These statistics were used as part of the criteria to determine the ideal number of latent classes (though they have no bearing on model fit).[160] Models with entropy values closer to 1 are preferable since they indicate a greater level of confidence in the assignment of individuals to specific classes. We also preferred models that provided sufficient sample sizes in each of the latent classes that would allow us to conduct further regression analyses.

The ability to define and characterize each class in a clear and meaningful manner was an important criteria used to select the latent model with the optimal number of classes. Although a higher number of classes may yield improvements in model fit, a high number of classes may make it difficult to adequately describe and differentiate each class in a way that is useful for the

purposes of this study. Ultimately, we chose a parsimonious model whose classes had sufficient sample sizes necessary for analyses, could be clearly defined, and provided a good statistical fit.

Participants were assigned to a particular class based on their highest posterior probability of assignment.[156] For example, if the latent class model determined that Participant 1 had an 80% probability of being assigned to Class 1, 10% probability of being assigned to Class 2, and a 5% probability of being assigned each to Class 3 and Class 4, Participant 1 would be assigned to Class 1. All individuals in the study sample (100%) had at least one posterior probability greater than or equal to 50%, 96% had at least one posterior probability greater than or equal to 75%, and 92% had at least one posterior probability greater than or equal to 90%, indicating a high degree of certainty in class assignment. Although this method does not take into account the uncertainty of class assignment, it minimizes the number of incorrect assignments compared to other approaches.[156]

Construct Validity Measures and Definitions

A total of 11 measures (8 sexual behaviors, 3 non-sexual measures), separate from those used to create the latent classes, were used to evaluate the construct validity of the perceived risk measure. Sexual behavior measures included: number of sex partners, any condomless anal intercourse (CAI), any insertive CAI, any receptive CAI, any sex with a HIV-positive partner, any sex with a HIV status unknown partner, awareness of all sex partners' HIV status, and any sex with a main partner. Non-sexual validation measures included condom attitudes with a new partner, HIV knowledge, and HIV testing frequency.

All sexual behavior measures were defined from sexual activities with male partners reported in the six months prior to the baseline interview. To improve the sensitivity of behavioral measures, data from participant-level questions (e.g., engaged in any CAI with any

male partner) and partner-level questions (e.g., engaged in CAI with a specific male partner) were used define these measures. At the partner-level, CAI was defined as not using a condom, using a condom part of the time, or occurrence of condom breakage. No CAI was defined as using a condom the whole time with that partner. All measures used in regression analyses were defined at the participant-level. Partner-specific data on CAI, receptive/insertive CAI, partner HIV status, and partner type were aggregated at the participant-level. Participant-level data included the total number of sex partners, number of sex partners by type (main/casual), and any CAI. Participants who reported no anal intercourse in the six months prior to baseline were coded as not having engaged in CAI, assuming that no anal intercourse was similar in HIV risk as having engaged in protected anal intercourse.

The awareness of partner HIV status measure was constructed based on a question asking participants whether they were aware of their partner's status the last time they had sex (prior to the baseline interview). If data for this question was missing, then disclosure before the first sexual encounter was used to define the partner status awareness measure. If the participant reported his partner's HIV status was seropositive before first having sex, the participant was coded as being aware regardless of what was indicated at last sex.

The HIV knowledge covariate was constructed using the Brief HIV Knowledge Questionnaire (HIV-KQ-18).[161] This measure is comprised of 18 separate True/False questions that had been previously validated within low-literacy populations.[161] We created a summary score that added up the correct answers to all 18 questions, with a score of 1 given for each correct response, and a score of 0 given for each incorrect response or a response of "Don't Know". Because the scores were so highly skewed to high levels of HIV knowledge, we dichotomized the score at its median (low scores ≤ 16; high scores > 16).

Main partnerships were defined as “someone that you feel or felt committed to above all others (someone you might call your boyfriend, significant other, life partner, or husband)”. A series of three questions (measured on a 5-point Likert scale) were used to assess condom use attitudes towards a new partner. Responses to the three questions were summed and dichotomized into positive vs. negative/neutral condom attitudes. See *Appendix A* for survey questions used to define all validation measures.

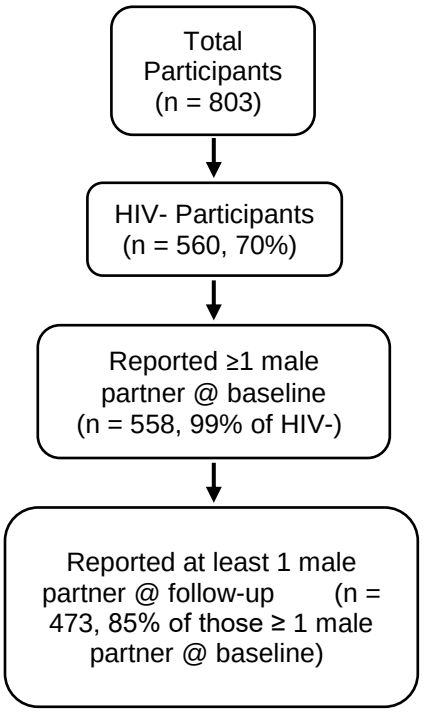
Study Population Restrictions

Our study sample consisted of HIV-negative participants who reported sex with at least one male partner at baseline and at least one male partner at follow-up (n = 473). In the second aim of this dissertation, we evaluate the relationship between HIV risk perception with both cross-sectional and longitudinal measures of sexual behaviors. Follow-up measures were only collected for HIV-negative participants, since follow-up did not occur for participants who tested positive at baseline. We restricted our study sample to participants who were HIV-negative at baseline so that we could conduct both sets of analyses within the same study population.

Participants who did not report any sex partners at follow-up were excluded from this analysis. Those who were lost to follow-up were also excluded. Participants who may had engaged in only oral sex with male partner(s) at follow-up were included. As described above, these participants were coded as not having engaged in any CAI.

Although we could have used a study sample consisting of participants who reported sex with at least one male partner at baseline only (n = 558), we further restricted our study sample to coincide with other aims of this dissertation (Figure 2.1). Participants who did not report a male partner at follow-up (n = 85) were more likely to be younger, Black, and have a high school or lower level of education (2-sided chi-square p-value < 0.05).

Figure 2.1. Sample Size Flowchart



A Priori Hypotheses for the 4-Class Latent Model

According to the principles of the Health Belief Model (HBM) and other health behavior theories, individuals who engaged in prior risky behaviors tend to have higher levels of perceived HIV risk, and those who previously engaged in protective behaviors tend to have lower levels of perceived HIV risk.[124-130] These patterns of behavior along with demographic characteristics of the latent classes were used to generate a priori hypotheses for each validation measure.

We selected the latent model with four classes as the "best" model (see results section). We expected low risk perceivers (Class 1 participants) to report fewer prior sexual risk behaviors (e.g., less CAI, fewer sex partners, less sex with HIV-positive or status unknown partners, higher likelihood of sex with a main partner). Because these participants believe they are at low risk for HIV infection, they should in theory have little reason to test frequently (for HIV), and should

have negative attitudes towards using condoms with a new partner. Given their younger age, we expected these participants to have a lower knowledge or awareness of HIV infection/transmission risks.

Because Class 2 participants (condom-derived risk perception) believe that condom use is the most effective tool in minimizing HIV risk (more-so than knowledge of partners' HIV status or sexual positioning), we expected them to use condoms more frequently compared to all other classes, and exhibit positive attitudes towards using condoms with new partners.

Class 3 participants (status-derived risk perception) should report fewer instances of sex with HIV-positive or status unknown partners. Higher levels of partner status awareness may correlate with having fewer sex partners and a preference for main partnerships. These participants may be more likely to engage in risky sexual behaviors if they are involved in long-term relationships, in which they are aware of their partner's serostatus. Class 3 participants may possess lower levels of knowledge regarding HIV transmission risk since they indicated that sex with HIV-positive individuals represented a risky act regardless of condom use or sexual position.

We expected Class 4 participants to have greater knowledge of HIV risks and engage in higher rates of (all types of) CAI. These participants may also have higher numbers of sex partners and fewer main partnerships since they seem most aware of ways to minimize risk of infection depending on the circumstance (e.g., insertive CAI with a HIV-positive or status unknown partner; any type of CAI with a seroconcordant partner).

Data Analyses

Regression Analyses

Unadjusted (bivariate) regression analyses were conducted using the 11 validation measures and the 4-class, latent perceived risk measure (as the outcome). Odds ratios, 95% CI, and p-values for participant-level validation measures were obtained using logistic regression.

Prevalence Estimates of Construct Validity Measures

Unadjusted prevalence estimates for the 11 validation measures were obtained for each of the four latent classes using the "modified Poisson" method.[162,163] This method enables us to obtain prevalence estimates with a robust error variance, leading to 95% CIs with the correct coverage. [162,163] The specifications within the GENMOD procedure in SAS for this method includes: log-Poisson distribution, 'repeated' statement with an independent covariance structure.[162] All analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC).

RESULTS

Study Population Description

Table 2.1. Study Population Description at Baseline (n = 473)

Characteristic	Total N (%)	Characteristics	Total N (%)
Age *		Currently Unemployed	90 (19.0)
18-29	322 (68.1)		
30+	151 (31.9)	Currently No Health Insurance	189 (33.8)
Race/Ethnicity *		Arrested in past 12 months	44 (9.3)
Black/African-American	208 (44.0)		
White/Caucasian	265 (56.0)	Illicit Drug Use in past 12 months	194 (41.0)
Education *			
High school, GED, or lower	67 (14.2)		
Some college or above	405 (85.6)		

Percentages may not add up to 100% due to rounding or missing values.
N = 473: refers to all HIV-negative MSM who reported at least 1 male partner during baseline and follow-up.

Table 2.1 provides baseline characteristics of the 473 HIV-negative MSM who reported at least one male partner at baseline and during the follow-up period by latent class. Overall, about two-thirds of participants were 29 years or younger and almost half were Black. Only 14% had a high school level of education or lower. Approximately one-fifth and one-third of the study sample reported they were unemployed, and had no health insurance at baseline. A small percentage were incarcerated and 41% reported using illicit drugs in the year prior to baseline.

Latent Class Model Selection and Definitions of Latent Typologies of HIV Risk Perception

Latent Class Model Fit Statistics

Table 2.2. Latent Class Model Fit Statistics

# of Classes	Deviance (G^2)	Entropy	AIC	cAIC	BIC	Adjusted BIC	Sample Size of Smallest Class N (%)
2	4943.34	0.93	5073.34	5408.7	5343.69	5137.4	209 (44.2)
3	4335.31	0.94	4531.3	5408.7	5343.69	5137.4	52 (11.0)
4	3892.71	0.94	4154.7	4830.6	4699.6	4283.8	39 (8.3)
5	3630.25	0.94	3958.25	4804.34	4640.34	4119.83	36 (7.6)
6	3407.97	0.94	3801.97	4818.31	4621.31	3996.06	36 (7.6)
7	3238.4	0.95	3698.4	4885	4655	3925.01	12 (2.5)

8	3097.58	0.95	3623.58	4980.42	4717.42	3882.7	8 (1.7)
9	2980.59	0.95	3572.59	5099.69	4803.69	3864.23	9 (1.9)
10	2849.37	0.95	3507.37	5204.71	4875.71	3831.52	8 (1.7)

Figure 2.2. Change in Model Fit Statistics across Latent Class Models

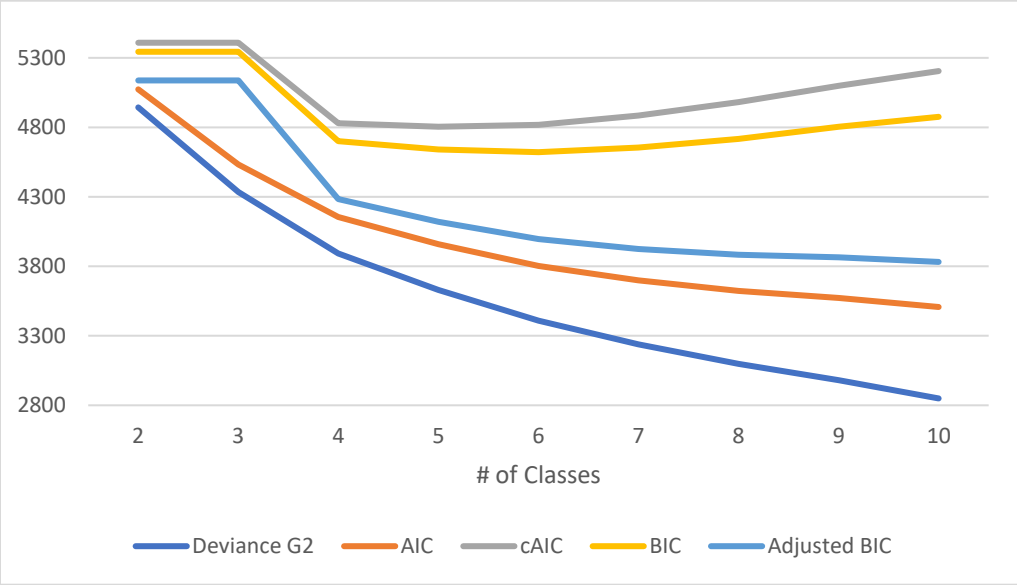


Table 2.2 provides a variety of fit statistics for latent class models containing 2-10 classes. As expected the deviance statistic (G^2) progressively decreased as the number of latent classes increased. All models had a high level of entropy, indicating that there was adequate separation between the classes. The largest decrease in fit statistics (cAIC, BIC, and adjusted BIC) for most models occurred when the number of classes increased from 3 to 4 (Figure 2.2). The rate of decline for these fit statistics stabilized (and even increased) for models with more than 4 classes. The smallest class dropped below 10% of the total sample for models containing 4 or more classes and dropped below 5% of the total sample for models containing 7 or more classes.

Defining Classes of the Latent Exposure Model

Table 2.3 below provides the item response probabilities for all 16 perceived risk inputs of the 4-class latent model. Class 1 exhibits minimal differentiation across all 16 inputs

compared to other classes. Most participants who fell into this class rated all 16 scenarios as low risk events. For example, 66% of participants categorized into this class rated unprotected receptive anal intercourse with a HIV-positive man not on ART as low risk. Based on the distribution of these probabilities, we defined participants in this class as men who have an overall low perceived risk of HIV infection. These participants did not believe their risk of HIV infection was high, regardless of the HIV status of the partner, condom use, or sexual position. This represented the smallest class with only 8% of all participants falling in this category.

The defining characteristic of Class 2 participants was the large magnitude of differentiation seen between protected and unprotected sex acts, regardless of partner status or sexual position. Only ~3% of these participants rated protected, insertive anal intercourse with a HIV-positive man not on ART as high risk, compared to ~83% rating the unprotected version of the same scenario as high risk. For this class, unprotected sex acts were consistently rated at higher risk levels than protected sex acts. This level of differentiation was evident across all partner types and sexual positions. The perception of HIV risk for Class 3 participants was largely dependent on condom use (protected vs. unprotected sex acts). Thirty-one percent of all participants were assigned to this class.

For Class 3 participants, the partners' HIV status played a prominent role in determining their perception of HIV risk. There were almost no participants who rated sex with HIV-positive partners (regardless of ART use) as a low risk act. In contrast, large proportions of Class 3 participants considered sex with HIV status unknown partners as low risk, and an even larger percentage reported sex with HIV-negative partners as low risk. There was little to no differentiation of risk by sexual position or condom use among HIV-positive partners. However, there was substantial separation of risk (more-so than Class 1 or 2) by sexual position, condom

use, and partner status among HIV-negative and HIV status unknown partners. Class 3 represented the largest class, including 32% of all participants.

All three factors: partner HIV status, condom use, and sexual position played an important role in influencing Class 4 participants' perception of HIV risk. The high magnitude of differentiation that was limited to HIV-negative and status unknown partners among Class 3 participants, was extended to all partner status types in this class. These data suggest these participants were knowledgeable about the risks associated with different sexual scenarios and partner types. Twenty-nine percent of participants were included in Class 4. The same general pattern of differentiation, in which protected sex acts were considered safer compared to unprotected sex acts, receptive anal intercourse was rated as riskier than insertive anal intercourse, and HIV-positive partners not on ART were identified as the highest risk group, followed by HIV-positive partners (on ART) with an undetectable viral load, status unknown partners, and HIV-negative partners, was present in all classes.

Table 2.3. Item Response Probabilities for 4-Class Latent Exposure Model

Classes	**1 = Low perceived risk**			**2 = Condom-derived perception**			**3 = Status-derived perception**			**4 = Fully informed perception**		
Probability of Membership	**8.3%**			**31.2%**			**32.0%**			**28.6%**		
Levels	Low	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High
Item Response Probabilities												
HIV- PIAI	87.2	10.2	2.6	98.6	1.4	0.0	77.6	16.5	5.9	86.6	11.9	1.5
HIV- PRAI	87.3	7.7	4.9	96.5	1.5	2.0	64.5	23.6	11.9	73.2	25.9	0.9
HIV- UIAI	86.6	10.7	2.8	41.0	24.0	35.0	36.0	19.6	44.4	32.6	31.0	36.4
HIV- URAI	79.0	13.2	7.8	21.6	24.5	53.9	21.8	22.3	55.9	14.3	30.6	55.1
HIV? PIAI	77.1	15.3	7.6	100.0	0.0	0.0	72.4	21.0	6.6	82.8	13.5	3.8
HIV? PRAI	84.7	12.8	2.5	90.7	7.1	2.2	50.8	28.8	20.4	57.4	37.3	5.3
HIV? UIAI	76.2	15.9	8.0	17.9	28.7	53.3	10.6	18.3	71.1	11.5	30.2	58.3
HIV? URAI	66.3	15.6	18.1	5.0	1.7	93.4	4.0	4.0	91.9	5.6	7.0	87.4
HIV+(arv) PIAI	94.6	0.2	5.3	96.3	3.0	0.8	1.3	13.7	85.1	33.7	63.3	3.0
HIV+(arv) PRAI	89.4	3.1	7.6	85.7	11.9	2.4	0.1	0.2	99.7	5.1	81.1	13.9
HIV+(arv) UIAI	96.3	0.1	3.7	13.2	20.7	66.1	0.0	0.0	100.0	2.1	23.6	74.4
HIV+(arv) URAI	81.1	5.1	13.8	1.4	6.0	92.7	0.0	1.3	98.7	0.0	9.1	90.9
HIV+(no arv) PIAI	84.2	2.9	12.9	75.6	21.7	2.7	0.7	0.9	98.4	6.9	57.1	35.9
HIV+(no arv) PRAI	84.3	0.2	15.6	60.7	31.1	8.2	0.0	0.7	99.3	0.1	43.3	56.7
HIV+(no arv) UIAI	78.8	2.6	18.6	1.3	16.1	82.6	0.0	0.0	100.0	0.8	6.2	93.1
HIV+(no arv) URAI	66.0	5.4	28.6	0.7	1.2	98.1	0.0	0.7	99.3	0.0	3.1	96.9

Notations: PIAI = protected insertive anal intercourse; PRAI = protected receptive anal intercrouse; UIAI = unprotected insertive anal intercourse; URAI = unprotected receptive anal intercourse

Selecting the 4-Class Latent Model

We selected the latent model with four classes for our exposure covariate based on multiple criteria. The 4-class model overall provided good statistical fit, produced distinct classes that could clearly be defined, and had adequate sample sizes in each class. Table 2.4 below shows the mean and median scores of the summary perceived risk (average of all 16 perceived risk scores) measure by latent class. Class 1 participants (low perceived risk) had the lowest average score and Class 3 participants (status-derived perception) had the highest average score.

Table 2.4. Distribution of Overall Perceived Risk Score by Latent Class

Latent Class	Mean (Median)
1 – Low Perceived Risk	2.6 (2.4)
2 – Condom-derived perception	5.4 (5.4)
3 – Status-derived perception	7.7 (7.7)
4 – Fully Informed perception	6.6 (6.5)

Study Population Description by Latent Class Typology

Low risk perceivers (Class 1) were more likely to be younger, Black, and uneducated compared to the other classes (Table 2.5). Condom-derived perceivers (Class 2) tended to be older, White, and well educated. Status-derived perceivers (Class 3) were younger and had similar distributions of White and Black participants. Fully-informed perceivers (Class 4) were similar in many characteristics to Class 2 participants. There were no statistical differences in unemployment, health insurance status, incarceration, and illicit drug use by latent class.

Table 2.5. Baseline Demographics of HIV-Negative MSM by Latent Class (N = 473)

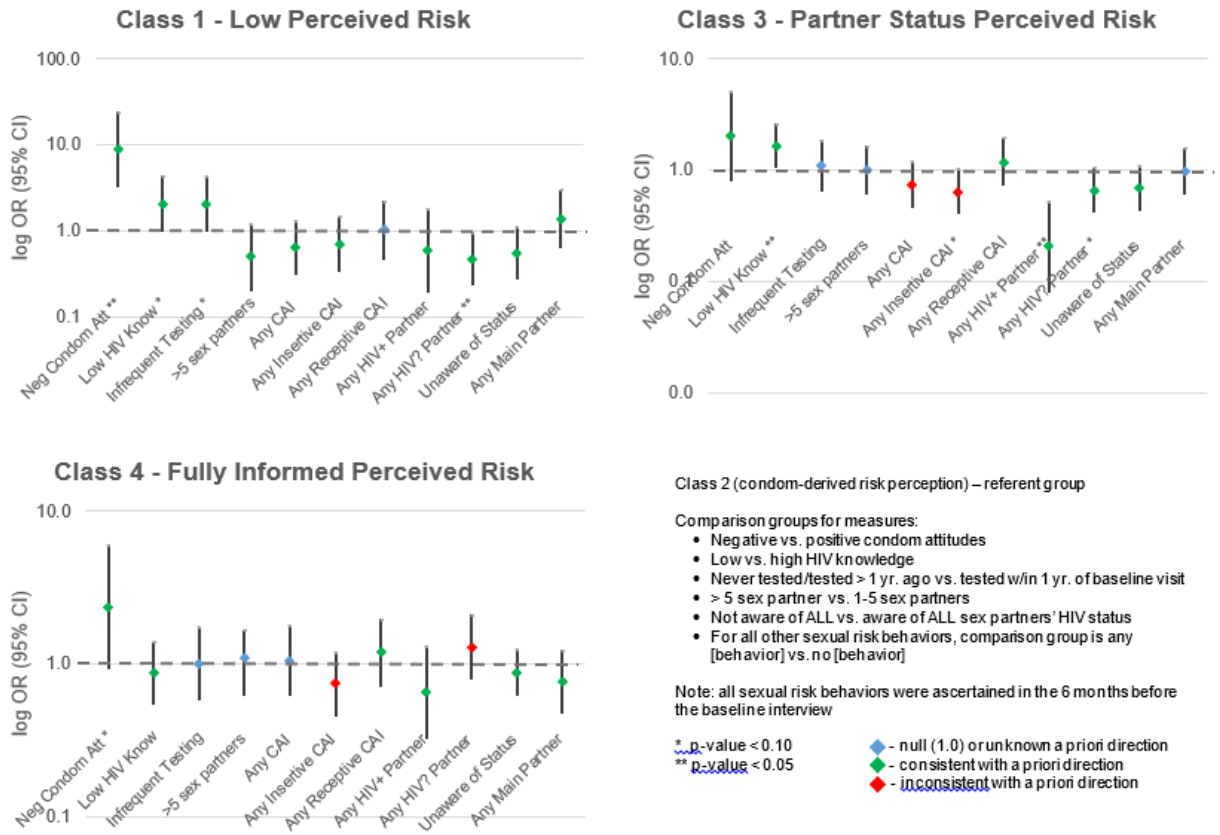
Characteristic	Low Perceived Risk (Class 1) N (%)	Condom-derived Perception (Class 2) N (%)	Status-derived Perception (Class 3) N (%)	Fully Informed Perception (Class 4) N (%)
Total	39 (8.2)	147 (31.1)	153 (32.3)	134 (28.3)
Age *				
18-29	32 (82.1)	85 (57.8)	120 (78.4)	85 (63.4)
30+	7 (18.0)	62 (42.2)	33 (21.6)	49 (36.6)
Race/Ethnicity *				
Black/African-American	26 (66.7)	58 (39.5)	70 (45.8)	54 (40.3)
White/Caucasian	13 (33.3)	89 (60.5)	83 (54.3)	80 (59.7)
Education *				
High school, GED, or lower	15 (38.5)	9 (6.1)	27 (17.7)	16 (11.9)
Some college or above	24 (61.5)	138 (93.9)	126 (82.4)	117 (87.3)
Currently Unemployed	12 (30.8)	24 (16.3)	32 (20.9)	22 (16.4)
Currently No Health Insurance	16 (41.0)	42 (28.6)	55 (36.0)	42 (31.3)
Arrested in past 12 months	5 (12.8)	12 (8.2)	12 (7.8)	15 (11.2)
Illicit Drug Use in past 12 months	16 (41.0)	58 (39.5)	66 (43.1)	54 (40.3)

Percentages may not add up to 100% due to rounding or missing values.
N = 473: refers to all HIV-negative MSM who reported at least 1 male partner during baseline and follow-up.
*Chi-square p-value < 0.05.

Construct Validity of Latent Perceived Risk Measure

Validating Latent Typologies of Perceived Risk against 11 Sexual and Non-Sexual Measures

Figure 2.3. Associations between Perceived Risk Typologies and 11 Validation Measures



Condom-derived risk perceivers (Class 2) were selected as the referent group since this class had an adequate sample size. Class 2 participants were most similar demographically to Class 4 participants. Consequently, we were interested in learning more about the other three classes.

Overall, the 4-class measure of HIV risk perception was strongly associated (type 3 p-value < 0.05) with five sexual behaviors and non-sexual correlates: condom attitudes with a new partner, HIV knowledge, sex with HIV-positive partners, sex with HIV status unknown partner, and partner status awareness.

Four validation measures were either strongly or moderately associated with low risk perceivers. Confirming our a priori hypotheses, Class 1 participants were less likely than Class 2 participants to have positive condom attitudes towards new sex partners, were less likely to test frequently, and were more likely to have lower levels of HIV knowledge (Figure 2.3). These participants were also less likely than Class 2 participants to engage in a variety of prior high risk behaviors including any CAI, any insertive CAI and sex with any HIV-positive or status unknown partner. Class 1 participants were less likely to be unaware of their partner's serostatus and more likely to report previous sex with a main partner.

Four sexual behaviors and non-sexual correlates were either strongly or moderately associated with status-derived risk perceivers. As expected, Class 3 participants were less likely than Class 2 participants to have sex with HIV-positive or status unknown partners. Because these participants were more likely to be engaged in seroconcordant sexual relationships, we assumed they would have engaged in high risk behaviors with these partners. However, these participants were less likely to report any CAI and any insertive CAI compared to Class 2 participants.

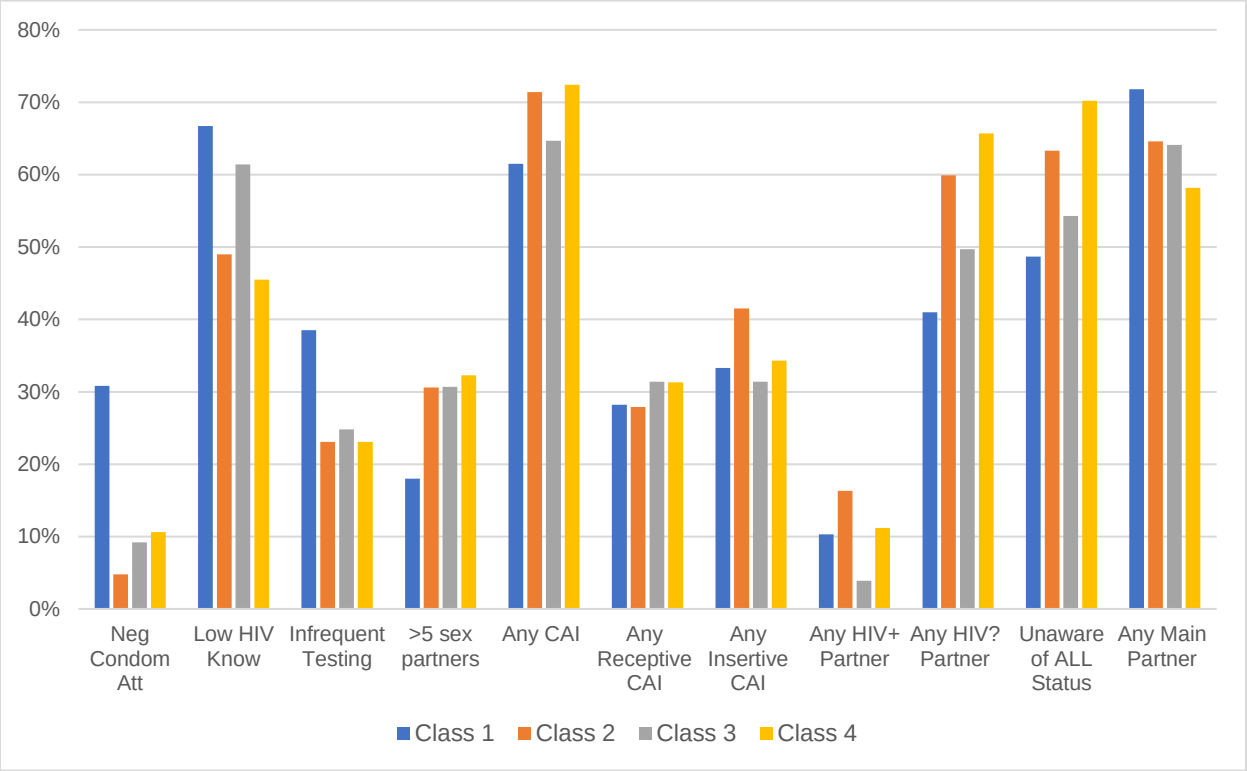
Only one validation measure (condom attitudes with a new partner) was associated with having a fully informed risk perception (Class 4). Although we expected these participants to engage in higher rates of insertive compared to receptive CAI (when compared to Class 2 participants) to minimize the risk of infection (i.e., seropositioning), results were inconclusive since both associations were statistically insignificant.

Prevalence of Behaviors by Perceived Risk Typologies

Class 1 participants had a high prevalence of negative condom attitudes, low HIV knowledge, and did not test for HIV frequently (Figure 2.4). Prevalence estimates for

participants from Class 2 and 4 were similar for many of the validation measures. Class 2 participants had the highest prevalence of any insertive CAI. Class 3 participants had a high prevalence of low HIV knowledge and the lowest prevalence for sex with any HIV-positive partner. Class 4 participants had the highest prevalence of being unaware of all sex partners' HIV statuses, and sex with any HIV status unknown partner.

Figure 2.4. Prevalence of Validation Measures by Latent Class



DISCUSSION

Summary

This study provides evidence supporting the validity of certain HIV risk perception typologies. Specifically, the low risk (Class 1) and status-derived (Class 3) typologies had moderate to strong associations (4/11 for Class 1; 4/11 for Class 3) with both sexual behaviors and non-sexual correlates in the correctly hypothesized directions. Although it may be reasonable to assume that beliefs are precursors to behaviors, alternatively, the opposite (i.e., behaviors shape beliefs) may also be true.[141] We found evidence of this relationship (where behaviors influence beliefs) among low risk perceivers, who reported fewer previous sexual behaviors than condom-derived risk perceivers. Although we did not compare low risk perceivers to the other two classes, the reported prevalence of numerous sexual behaviors were lower for Class 1 participants compared to the other three classes. Previous studies also found an inverse association between past behaviors and HIV risk perception, though their ordinal categorization of perceived risk is unlikely to be comparable to the latent typologies used here.[132,134,149]

Results also confirmed that status-derived perceivers (Class 3) were less likely to engage in previous sex with a known, HIV-positive partner compared to condom-derived risk perceivers. Likewise, Class 3 participants had the lowest prevalence of reported sex with any HIV-positive partner. The literature describing the frequency of "serosorting" (act of having sex with a partner of the same HIV status), its effectiveness, and the subpopulations of MSM who engage in this risk-reduction behavior is extensive.[164-167] The strong correlation between this perceived risk typology and past sexual behaviors provide suggest that these latent typologies may be useful in predicting future behaviors.

Only one validation measure was moderately associated with the fully informed risk perception typology (Class 4). One of the reasons for the null associations may be the similarity between this group and the comparison group (condom derived risk perceivers – Class 2). According to Table 2.5, both groups were comparable in race, employment, insurance status, incarceration, and illicit drug use. Figure 2.4 presents information that helps to differentiate these two classes. While both classes reported high rates of various sexual behaviors, Class 2 participants had a high prevalence of any insertive CAI and any sex with a HIV-positive partner. If Class 2 participants were more likely to engage in insertive CAI with HIV-positive partners, this would suggest that these participants are engaging in seroadaptive behaviors (i.e., seropositioning) to minimize the risk of infection, though our results do not show this. In contrast, Class 4 participants had a lower prevalence of partner HIV status awareness and any sex with main partners. The main source of risk for fully-informed risk perceivers may come from status-unknown, casual sex partners. The risk of HIV infection may be high for this group since the results suggest that Class 4 participants may be less likely to use condoms with new or casual partners (Class 4 participants were more likely to have negative condom attitudes with new partners compared to Class 2 participants).

Strengths & Limitations

A major strength of this study was its novel conceptualization of perceived HIV risk. Latent class analysis allowed us to identify subgroups of participants who thought about their risk of HIV infection in different ways, prioritizing certain partner types or sexual activities over others. Most of the previous literature utilized an ordinal measure (categorized from Likert scales) of risk perception.[133,138,142] Asking individuals to rate their level of perceived risk on a numeric scale may be problematic since they may have problems objectively making judgements

about their risk of HIV infection (which itself is a low probability event) in terms of probabilities or odds.[80] Prior studies commonly used ambiguous measures of perceived risk that did not make HIV risk perception conditional on specific behaviors or partner characteristics. This study incorporated conditional, partner-specific questions to identify the factors young MSM value most when thinking about their own risk of HIV infection.

The lack of partner-specific analyses is a primary limitation in this study. Because perception of risk can vary from one sexual partner to the next (depending on characteristics specific to the partner), conducting a participant-level analysis that combines the potentially different effects across all partners (of the same participant), may obscure the relationship between risk perception and behaviors. Naïve analyses that do not account for correlated data can result in biased standard errors for regression parameters, even though parameter estimates are unlikely to be affected.[168] Although partner-level data were available for a few of the validation measures (e.g., CAI, insertive/receptive CAI, partner HIV status, partner status awareness, partner type), the results remained the same when using partner-level data (*Appendix B*).

A potential source of misclassification may come from the use of a 4-class latent model of risk perception. An argument can be made for the use of a 3-class model since one of the typologies was not associated with many validation measures. When compared against the 4-class categorization, the 3-class measure (that essentially combines Class 2 – condom-derived perceivers with Class 4 – fully informed perceivers into a single class) had the same number of validation measures (4/11) it was either moderately or strongly associated with (*Appendix B*).

Because LCA had never been used to create a measure of perceived HIV risk, we believed it was appropriate to assess for construct validity using both sexual behaviors and other

health (non-sexual) related measures. Future analyses using this type of measure should control for potential confounders (e.g., demographic characteristics, sexual behaviors, and partner characteristics). All validation constructs used were obtained via self-report. HIV-related risk behaviors are often prone to social desirability bias due to the stigma associated with these behaviors, and the people engaged in them.[84,85,169] Any differential misclassification of the validation measures by latent class or other characteristics (e.g., race) may result in biased effect estimates. All analyses were completed using cross-sectional data, making it difficult to establish temporality and assess for causal effects.

Public Health Importance

This study demonstrated how certain perceived risk typologies were correlated with past behaviors, attitudes, and knowledge. However, we do not know if these latent typologies perform any better or worse when compared to typical, ordinal measures. A sensitivity analysis should be conducted that compares results using an ordinal categorization of a summary perceived risk measure (e.g., sum the responses to all 16 inputs and categorize the summary score into low/high levels of perceived risk) to the results from the latent typologies. If the validation measures better correlate with an ordinal, summary measure, this may indicate that the use of questions conditional on sexual behaviors and partner characteristics may not be necessary when measuring perceived risk. A single, unconditional question may suffice.

Further analyses are needed to assess whether these typologies can also predict future sexual behaviors. If so, these measures may be used to identify subpopulations of MSM at high risk for HIV infection. For instance, we may find that one typology is characterized by high rates of CAI with sex partners of unknown HIV status. Interventions that promote condom use and facilitate disclosure of HIV status can be delivered to members of this group. Another typology

of risk perception may consist of individuals who frequently engage in unprotected sex with HIV-positive partners with detectable viral loads. These individuals may benefit from biomedical interventions such as PrEP. Analyses from Aim 1 were not sufficient to identify a perceived risk typology that exhibited specific patterns of risky behaviors. In Aim 2, we explored the relationship between these typologies of perceived risk with both past and future sexual behaviors.

Racial differences in the way young MSM perceive their risk of HIV infection, and racial differences in the effect of risk perception on sexual behaviors may contribute to racial disparities in HIV diagnoses. In this study, we developed risk perception typologies from a sample of young White and Black MSM. The typologies identified in this study may differ from those developed from a sample including only YBMSM. For example, YBMSM may think about their own risk of infection on an individual-level, using an ordinal scale: 1) they believe they are at low risk for infection, or 2) they believe they are at high risk for infection. In contrast, White MSM may think about their risk of infection by accounting for both individual-level (e.g., PrEP) and dyadic factors (e.g., partner's HIV status). Differentiating risk perception typologies by demographic factors (e.g., race) can help to inform the development and efficient delivery of targeted HIV prevention strategies.

Future studies should incorporate questions that measure perceived risk conditional on multi-level factors. For example, perceived risk may be elevated in communities with high levels of HIV-related stigma, or in geographic regions where there are high rates of poverty and poor access to health care facilities. These can further refine the measurement of perceived risk (on top of the individual-level behaviors and dyadic characteristics that were incorporated into the

typologies developed in this aim) to better predict future behaviors, and identify subpopulations at high risk for HIV infection.

Conclusion

This study utilized questions conditional on sexual behaviors and partner characteristics to identify unique latent typologies of HIV risk perception among a sample of young HIV-negative Black and White MSM. We validated these perceived risk typologies against prior reported sexual behaviors and non-sexual correlates of HIV risk, demonstrating that previously reported behaviors were associated with participants' perception of HIV risk. Future studies should look to further refine and validate this measure against relevant constructs, and assess whether these typologies are accurate in predicting future HIV risk behaviors.

CHAPTER 3. EVALUATING THE RELATIONSHIP BETWEEN A LATENT MEASURE OF HIV RISK PERCEPTION AND SEXUAL BEHAVIORS AMONG YOUNG, HIV-NEGATIVE MSM IN ATLANTA, GA

INTRODUCTION

Theoretical Framework of the HIV Risk Perception-Sexual Behavior Relationship

The relationship between risk perceptions and sexual behaviors may occur in a reciprocal manner, where past behaviors influence an individual's current perception of HIV risk (reflective hypothesis), which in turn, may motivate future behaviors (motivational hypothesis).[132-134,141] For instance, if an individual were engaged in risky sexual activities in the recent past, that might lead to the belief that he is at elevated risk of becoming infected with HIV. Subsequently, this high level of risk perception may bring about a decrease in the frequency of high risk sexual activities in the future (Figure 3.1).

Figure 3.1. Reciprocal Relationship between Risk Perception and Sexual Behaviors

For the most part, findings have been mixed with some studies showing a positive, an inverse, or null relationship between perceived risk and sexual behaviors (e.g., CAI).[65,76-78,123,144,152] Researchers have suggested that the frequent use of cross-sectional study designs and inadequate control of important multi-level factors may have contributed to the lack of consistent study findings.[80,81]

Limitations of Cross-Sectional Study Designs

Prior studies have been hampered by study design issues limiting their ability to appropriately evaluate the relationship between perceived risk and behaviors. A cross-sectional design fails to maintain the temporal relationship between perceived risk and sexual behaviors, making it impossible to determine whether study results pertain to the reflective or the motivational hypotheses.[132,134,145,146] These designs allow the causal mechanisms of both hypotheses to be present, sometimes simultaneously, producing inconsistent findings.[80,132,145] A cross-sectional design may be adequate to assess the relationship between past behaviors and perceived risk (reflective hypothesis).[134,146] Unless an outcome measuring the intention to change behaviors is utilized, longitudinal data would be required to test the motivational hypothesis.[146]

Among 18 studies that evaluated the relationship between HIV risk perception and sexual behaviors, 17 of them utilized a cross-sectional design or analysis (*Appendix C)*. Of these 17 studies, 7 reported positive associations (condom use increases as perceived risk increases), 7 reported negative associations (condom use decreases and perceived risk increases), 2 reported both positive and negative associations, and 1 reported null findings.

Analytical Study Limitations

Multi-level factors, particularly dyadic (partner) characteristics can influence one's perception of risk and the types of sexual behaviors they engage in. Ignoring these factors that serve as potential confounders or moderators can result in biased effect estimates that do not reflect the true nature of the perceived risk-behavior association.[134] A few cross-sectional studies collected data on dyadic, behavioral outcomes conditional on sexual position (e.g., insertive CAI), partner HIV status (e.g., insertive CAI with HIV-negative partners), and partner type (e.g., CAI with casual partner).[76,78,133,139,152] All outcomes for these five studies were aggregated at the

individual-level (not tied to a specific partner) and represented behaviors that occurred before the measurement of risk perception. Results from these five studies were mixed with three finding positive associations and two finding negative associations between HIV risk perception and condom use.[76,78,133,139,152]

Two other cross-sectional studies collected dyadic outcomes on behavioral intentions to use condoms in the future (e.g., intention to use condoms consistently with regular partners).[132,149] These studies found that elevated levels HIV risk perception was associated with intentions to use condoms in the future, lending support to the motivational hypothesis.[132,149] Although these outcomes described intention to use condom conditional on dyadic (partner) characteristics, they represented hypothetical behaviors with partners that may not have existed. To our knowledge, only one study utilized longitudinal, partner-level behavioral outcomes (condom use at last intercourse with a partner).[79] This study found a positive association between higher levels of perceived risk at baseline and subsequent condom use.[79] No studies have adequately accounted for partner-level characteristics including the partner's HIV status or partner type in their analysis (*Appendix C)*.[81]

Literature Review of Studies Evaluating the Reflective and Motivational Hypotheses

Few studies specified whether they were testing the reflective or motivational hypothesis in their analysis. In a study conducted among mostly White, female college students, Reisen et al. found no association between a partner-specific measure of perceived risk and prior condom use (no evidence supporting the reflective hypothesis).[79] Using the same sample as before (within a longitudinal design), the authors found that greater levels of partner-specific perceived risk predicted higher levels of condom use with that partner (evidence supporting the motivational hypothesis).[79] In another study among Chinese male injection drug users, Tsui et

al., found that an unconditional measure of HIV risk perception was significantly associated with past syringe sharing (those with higher levels of perceived risk were more likely to have shared syringes in the past), but not associated with past condom use (providing partial support for the reflective hypothesis).[132] Using partner-specific measures of risk perception, the authors found that higher levels of perceived risk was positively associated with *intentions* to use condoms consistently in the next six months among main partners, casual partners, and female sex workers (providing partial support for the motivational hypothesis).[132] A literature review comprising older studies published in the late 1980's to early 1990's found evidence supporting the reflective hypothesis among cross-sectional studies, but no evidence supporting the motivational hypothesis.[134]

Relationship Perceived HIV Risk and Awareness of Sexual Partner's HIV Status

HIV status disclosure has been promoted as an effective HIV risk-reduction strategy since the U.S. Public Health Service recommended it in 1987.[81,176,177] Mathematical models have shown that disclosure can result in an 18-45% reduction in HIV transmission.[178,179] HIV risk perception may also play a role in influencing one's awareness of their partner's HIV status in the same way it affects condom usage. For example, an individual who believes he is at high risk for HIV infection may be more willing to engage in serodiscussion with future partners to minimize their risk of infection. We found no studies that have directly evaluated the relationship between perceived risk and partner status awareness.

Multi-level Factors Contributing to Racial Disparities in HIV

As discussed previously, individual-level sexual behaviors do not seem to explain the large Black-White disparities in HIV diagnoses among MSM. Previous studies have shown that White MSM engage in more CAI than Black MSM.[8,10-14] Instead, substantial Black-White

differences in dyadic or structural factors facilitating HIV risk may contribute to racial disparities in HIV. For instance, dyadic differences in partner status awareness have been found between Black and White MSM, with Black MSM less likely to be aware of their partners' HIV status compared to White MSM.[190-192]

Differences in the effect of perceived risk on sexual behaviors (at the partner-level) between Black and White MSM may also help to explain the unequal distribution of disease. For instance, high levels of perceived risk may prompt White MSM to increase the frequency of serodiscussion with future sex partners, but may have no effect among Black MSM. Or elevated levels of perceived risk may result in increases in condom use among Black MSM, but have no effect among White MSM. Further research is needed to explore how the effect of perceived risk on sexual behaviors may differ at multiple levels (i.e., differ by individual and partner-level factors).

Study Purpose, Aims, and Hypotheses

Study Purpose

The purpose of this study is to evaluate how past risk behaviors shape perception of HIV risk, and in turn, how perceived risk influences future risk behaviors among young, HIV-negative MSM residing in the metro Atlanta area. Few studies have explored these relationships among either HIV-negative or young MSM in the United States.[76,135,152]

Unlike previous studies, behavioral outcomes at the partnership-level (partner-specific CAI, awareness of partner's HIV status) were utilized. Additionally, dyadic characteristics including the partner type and partner's HIV status were incorporated into the analysis. This allowed us to assess whether the association between perceived risk and sexual behaviors

differed at the individual-level by race, and at the dyadic-level by partner type and partner HIV status.

There were a few differences between the validation of the latent measure of perceived risk in Aim 1, and evaluating the association between prior behaviors and risk perception in Aim 2. Both aims included measures of past sexual behaviors. However, validation results from Aim 1 were obtained from bivariate models, whereas the results for Aim 2 came from multivariate models. Aim 1 also included non-sexual behaviors (e.g., HIV testing frequency, condom attitudes) as outcomes of interest since the purpose of that aim was to assess whether the various typologies of perceived risk were correlated with a variety of HIV-related risk factors. In Aim 2, we focused on sexual behaviors as the outcomes of interest and incorporated multi-level factors into the analyses.

Study Aims

1. To evaluate the association between a latent measure of HIV risk perception (developed from questions conditional on sexual behaviors and dyadic partner characteristics) and a participant-level measure of prior CAI. This was a cross-sectional analysis in which both the perceived risk and CAI were measured at baseline.
2. To evaluate the associations between a latent measure of HIV risk perception and two longitudinal, partner-level outcomes: CAI and partner HIV status awareness. Both outcomes were measured prospectively, after the baseline measurement of perceived risk.

a. To assess whether the association between perceived risk and both outcomes differ at the individual-level by participant race and at the dyadic-level by partner type (main/casual) and partner HIV status (for CAI outcome only).

Study Hypotheses

According to behavior change theories, those who report high levels of past risk behaviors should possess higher levels of risk perception (and vice-versa) providing evidence supporting the reflective hypothesis.[124-130] Likewise, those with high levels of perceived risk at baseline may engage in safer behaviors at follow-up. Because the latent measure of perceived risk is not ordered, our findings may not conform to the stated mechanisms of the reflective and motivational hypotheses. Instead, we expect the perceived risk typologies to correlate with behaviors based on the specific pattern of characteristics used to construct each latent class.

We expect low risk perceivers (Class 1) to have reported safer behaviors at baseline (less CAI, more awareness of partner status). At follow-up, these participants may continue to engage in safe behaviors, thus justifying their low perception of risk. Following the mechanisms of the motivational hypothesis, these participants may also engage in high risk sexual activities at follow-up because they believe they are not at risk for HIV infection.

We expect condom-derived risk perceivers (Class 2) to report less CAI both at baseline and at follow-up, since they place the most value in condom use when evaluating their perception of HIV risk. These participants may be less aware of their partner's HIV status if they utilize condoms as their primary means of prevention.

We expect status-derived risk perceivers (Class 3) to avoid sex with HIV-positive partners at baseline and at follow-up. Since their partner's HIV status is important in the evaluation of their risk perception, we expect these participants to be more aware of their

partner's status compared to other classes. Condom use for these participants may be limited if they are mostly having sex with seroconcordant (HIV-negative) partners.

We expect fully-informed risk perceivers (Class 4) to be more likely to engage in CAI and less likely to be aware of their partner's HIV status both at baseline and at follow-up. These participants valued all three factors (sexual position, condom use, and partner HIV status) equally when assessing their perception of risk. Consequently, these participants may be best equipped to minimize risk using different tactics. For example, when having sex with HIV-positive partners with a detectable viral load or status unknown partners, they may be more likely to use condoms. When having sex with HIV-negative (seroconcordant) partners, these participants may be less likely to use condoms.

METHODS

InvolveMENt Study Description

The data that was used for this analysis came from the InvolveMENt study, which was a prospective cohort study conducted at Emory University. This study was designed to identify multi-level factors (individual, dyadic, and structural) that contribute to racial disparities in HIV (and sexually transmitted infections) prevalence and incidence among Black and White MSM living in Atlanta, GA.[16] A survey collecting information on the following domains: demographics, psychosocial scales, community characteristics, individual-level HIV risk behaviors, and a dyadic inventory of the 5 most recent sex partners in the last 6 months was administered at baseline and at each follow-up session (6, 12, 18, 24 months). Study discontinuation occurred after the 24-month visit or HIV seroconversion, whichever came first.[16] Further information about the InvolveMENt study including the recruitment and eligibility criteria can be found in the previous aim.

Study Measures and Definitions

Condomless Anal Intercourse (CAI) Definition

We utilized a participant-level outcome (one outcome per participant) when testing the reflective hypothesis. The outcome was defined as engaging in any CAI in the past 6 months. Participants who reported having engaged in CAI with any of their (up to 5) sex partners in the past 6 months, or those that engaged in any CAI in the past 6 months (not specific to any partner), were coded as having the outcome.

A partner-level measure of CAI was used when evaluating the motivational hypothesis. Each participant has potentially multiple outcomes, given that he reported multiple partners during the follow-up period. Starting with the 12-month survey, participants were administered

an abbreviated version of the questionnaire in which the questions regarding insertive or receptive CAI at last sex were excluded for newly reported partners. We used both partner-specific questions measuring any CAI in the past 6 months and questions regarding insertive/receptive CAI at last sex to construct the covariate. Those participants who engaged in protected (used the condom "the whole time") receptive or insertive anal intercourse at last sex and reported not engaging in any CAI with that partner in the past 6 months were coded as not having the outcome. Participants who engaged in receptive or insertive anal intercourse at last sex (didn't use a condom, used a condom only a part of the time, or the condom broke during sex) or who reported any CAI with the partner in the past 6 months were coded as having the outcome.

Using both sets of questions helped to maximize the sample size and increased the sensitivity of the CAI outcome. Excluding the CAI at last sex questions would have severely restricted the sample size (missing out on 2,496 observations), and excluding the general CAI (in last 6 months) question would have left out any new partners reported at or after the 12-month follow-up visit (representing 12% of all new partners).

For both the participant-level (baseline) and the partner-level (longitudinal) outcomes, those who reported no anal intercourse at all (with partners and in general) were coded as not having engaged in CAI. We assumed that no anal intercourse was similar in HIV risk as having engaged in protected anal intercourse. This also allowed us to maximize our sample size for the longitudinal analysis (67% of all partners, n = 3,401 reported no anal intercourse throughout the follow-up period).

Even though we potentially had data on multiple measurements of partner-level CAI (participants attended up to 4 follow-up visits), we only used the first (or earliest) reported

occurrence (yes/no) of partner-level CAI at follow-up as the primary outcome of interest. In other words, the partner-level CAI outcome was constructed from information collected at the first follow-up visit in which the participant indicated he had sex with a partner.

Partner HIV Status Awareness Definition

The secondary outcome of interest is a longitudinal, partner-level measure of partner HIV status awareness. For new partnerships that were first reported during the follow-up period, only the question regarding disclosure at first sex was used to define the outcome. If an existing partnership was reported at baseline and either disclosure at first sex did not occur, or the partner was HIV-negative, then the question regarding disclosure at last sex was used to define the outcome. Partnerships reported at baseline in which the partner's HIV status was positive were excluded from the analysis. Disclosure occurred if: 1) both the participant and partner discussed each other's HIV status before first having sex (for new partners reported during follow-up), or 2) if the participant was aware of the partner's status at last sex (for previously reported partners whose status was unknown or seronegative at last study visit).

Even though we potentially had data on multiple measurements of partner status awareness over the entire follow-up period (e.g., was unaware at 6-month follow-up, but became aware at 12-month follow-up visit), we only used the first (or earliest) reported occurrence of being aware/unaware of their partner's HIV status as the secondary outcome of interest. In other words, the partner HIV status awareness outcome was constructed from information collected at the first follow-up visit in which the participant indicated he had sex with a partner.

Definitions for Multi-Level Factors

Individual and partner-level (dyadic) factors were included in the models evaluating the relationship between perceived risk and sexual behaviors. Data on individual-level factors

including participant demographics (age, race), socioeconomic status (education, employment status, health insurance status), risk behaviors (incarceration/illicit drug use in the past 12 months), and HIV knowledge were collected at baseline. At each study visit, dyadic, partner-level data including age, race, HIV status, and type were collected.

Those who reported either paid part time (< 30 hrs./week) or full time (> 30 hrs./week) employment were defined as currently employed. Aim 1 provides further details on definitions regarding HIV knowledge and partner type.

Only partner-level covariates that were measured during the follow-up period were used when testing the motivational hypothesis. To evaluate the reflective hypothesis, partner-level covariates (HIV status, partner type, CAI) measured at baseline were aggregated at the participant-level.

Data Analyses

Study Population Restrictions - Reflective Hypothesis (CAI)

The same exclusion criteria for the partner-specific CAI outcome were used for the participant-level baseline CAI outcome (n = 473) below.

Study Population Restrictions – Motivational Hypothesis (CAI)

For the partner-specific CAI outcome, we restricted our analyses to HIV-negative MSM participants who reported having sex with at least one male partner during the follow-up period (n = 473). These 473 participants reported 2,471 distinct, male sexual partners over the entire follow-up period (Figure 3.2). We did not include baseline partners unless participants reported having sex with them again during the follow-up period, because we wanted to establish temporality between the baseline exposure (perceived risk) and the outcome (CAI) at follow-up.

Because we did not collect multiple measurements of perceived risk, the first report of CAI (yes/no) during the follow-up period was used to minimize the time between the exposure and outcome, given that the effects of perceived risk may diminish over time. Only ~14% of all reported sexual partnerships were comprised of partners who were reported more than once during the follow-up period. Although the distribution of first reported (yes/no) CAI decreases over time, there remains a significant proportion of partnerships in which the time between baseline exposure and the reported outcome is lengthy (Table 3.1). We did not conduct a survival analysis that took into account the time between the measurement of the exposure and both partner-level outcomes, which may vary from one participant to another.

Figure 3.2. Motivational Hypothesis Sample Size Flowchart for CAI Outcome

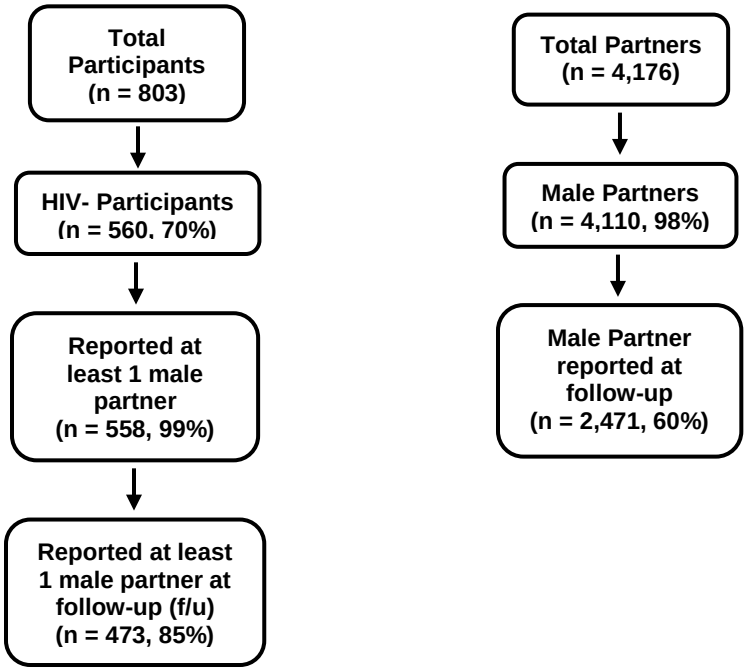


Table 3.1. Distribution of Reported Partnerships and Risk Behaviors (N = 2,471)

Partner-Level Characteristics	N (%)
Frequency of Reported Sex Partnerships Over Entire F/U Period	
Partner only reported once	2,134 (86.4)
Same partner reported twice	205 (8.3)
Same partner reported three times	74 (3.0)

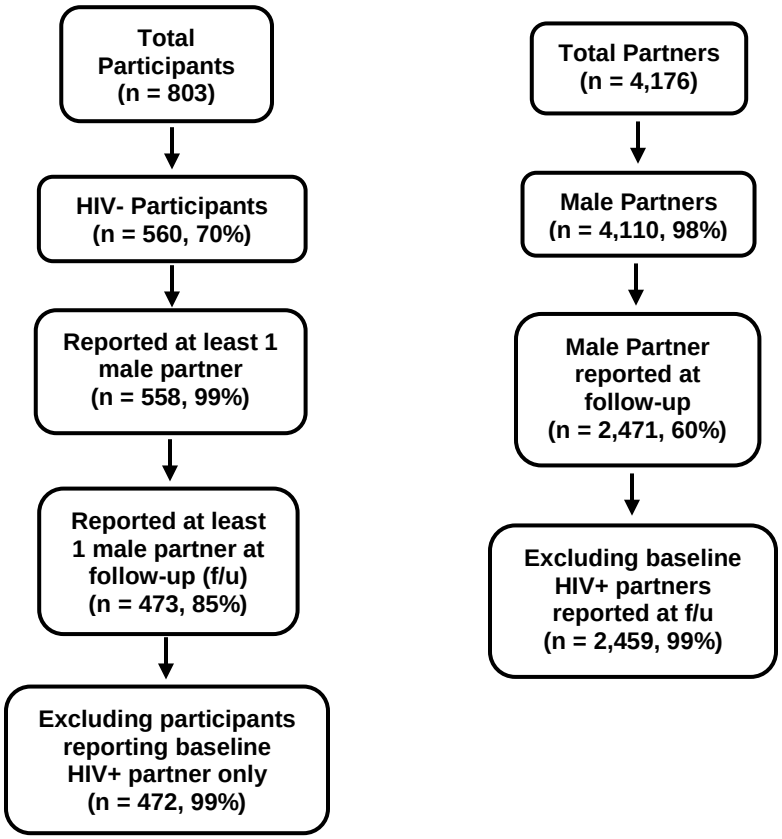
Same partner reported four times	58 (2.4)
Distribution of First CAI (yes/no) by Partner	
First CAI reported at 6 month f/u	897 (36.3)
First CAI reported at 12 month f/u	515 (20.8)
First CAI reported at 18 month f/u	415 (16.8)
First CAI reported at 24 month f/u	360 (14.6)
Distribution of First Disclosure (yes/no) by Partner [1]	
First disclosure reported at 6 month f/u	854 (34.7)
First disclosure reported at 12 month f/u	601 (24.4)
First disclosure reported at 18 month f/u	491 (20.0)
First disclosure reported at 24 month f/u	411 (16.7)

[1] N = 2,459 (excludes baseline HIV+ partners who were reported again during follow-up).

Study Population Restrictions – Motivational Hypothesis (Partner Status Awareness)

For the partner status awareness outcome, we followed the same exclusion criteria as the partner-level CAI outcome. Additionally, we excluded any HIV-positive partners that were reported at baseline since the partners' HIV status would be fixed from that point in time, and knowledge of partners' status would have occurred prior to the exposure measurement. The final sample size for this analysis included 472 participants and 2,459 partners (Figure 3.3). Baseline partners who were either HIV-negative or whose status were unknown were included in the analysis if the participant reported having sex with them again during the follow-up period. Recognizing that HIV status disclosure is an ongoing process, these partnerships were included since their status could change in the period between the baseline and the follow-up visit. For all analyses, we used the first occurrence of partner status awareness (yes/no) during the follow-up period to ensure temporality and to also minimize the time between the measurement of perceived risk and the outcome. The distribution of first occurrence of partner status awareness was similar to that of the first occurrence of CAI (Table 3.1).

Figure 3.3. Motivational Hypothesis Sample Size Flowchart for Partner Status Awareness Outcome



Regression Analyses - Reflective Hypothesis

Multinomial (for the perceived risk measure) and binary (for baseline CAI) logistic regression models were used to obtain odds ratios and 95% confidence intervals for the following covariates: individual-level demographics (age, race, education, employment, health insurance status, HIV knowledge) and individual-level risk behaviors (incarceration, illicit drug use, any CAI, sex with any HIV-positive partner, sex with any HIV-negative partner, sex with any status unknown partner, sex with any main partner, sex with any casual partner).

To construct a parsimonious model, only covariates that were statistically significant (p-value < 0.05) in bivariate regression models either with the exposure or outcome were included

in multivariate regression analyses. All covariates included in bivariate regression analyses were identified as those known or suspected to act as potential confounders in previous literature. Those covariates only associated with the exposure were included in multivariate models since we believed they were important factors to control for.

The multivariate model regressing risk perception included the following variables: exposure (baseline CAI), individual-level demographics (age, race, education, HIV knowledge), and individual-level risk behaviors (drug use, sex with any HIV-positive partner, sex with any HIV-negative partner, sex with any status unknown partner, sex with any main partner).

Regression Analyses – Motivational Hypothesis (CAI)

Because some participants reported more than one partner during the follow-up period, we had to account for the potential correlation of outcomes between partners of the same participant. Sexual behaviors across partners of the same cluster (participant) may be similar. However, studies have found that the most of the variance in condom use behaviors occur at the partner-level rather than being stable at the participant-level.[180,181] In other words, condom use is largely dependent on partner-level characteristics rather than individual-level factors. Although parameter estimates are unlikely to be affected, naïve analyses that do not account for correlated data can result in biased standard errors for regression parameters.[168] Generalized estimating equations (GEE) were used to construct marginal models that account for correlated outcomes.[182] The GENMOD procedure was used for all models since it automatically incorporates a marginal GEE model using the 'repeated' statement and no additional specification is required to produce empirical standard errors.[183] The GLIMMIX procedure was not used since we were not interested in incorporating random effects into our models.

All models (unadjusted and adjusted) used a log-Poisson distribution to obtain effect/error estimates since the log-binomial distribution did not converge for many multivariate models.[162] For unadjusted models where the dependent and independent inputs were both participant-level covariates, the "modified Poisson" method (inclusion of a 'repeated' statement, log-Poisson distribution, and independent covariance structure) was used to obtain risk ratios with a robust error variance estimation, leading to 95% CIs with the correct coverage.[162,163] For all other models, we initially selected the correlation structure yielding the best model fit (smallest QIC score), though many of them failed to converge (for multivariate models).[184] We used the exchangeable correlation structure, which assumes that all observations within the cluster (partners of the same individual) are correlated in the same manner, since it was compatible with all bivariate and multivariate models. GEE methods are robust to the choice of correlation structure such that if the selected structure does not match the true model-based structure, the resulting estimates remain statistically consistent.[183]

Unadjusted regression models were run for both the exposure (participant-level perceived risk) and outcome (partner-level CAI). The GENMOD procedure was used to obtain unadjusted risk ratios and 95% confidence intervals for the following: individual-level covariates (age, race, education, employment, health insurance status, HIV knowledge, incarceration, drug use) and dyadic covariates (partner age, partner race, CAI, partner type, partner HIV status). For bivariate analyses involving dyadic, multinomial outcomes (partner HIV status, partner race), we constructed dichotomous covariates to investigate the unadjusted associations separately (the GENMOD procedure did not support methods for obtaining risk ratios using a multinomial distribution with correlated data). For example, an independent variable comparing HIV-negative

to HIV-positive partners (setting status unknown partners to missing) was used in the unadjusted model.

Statistically significant (p-value < 0.05) covariates (with either the exposure or outcome) used in the multivariate model regressing the outcome (partner-level CAI) included: perceived risk (exposure), individual-level variables (age, race, education, HIV knowledge), and partner-level variables (partner type). Despite a non-significant p-value, the partner HIV status covariate was also included in final multivariate models since it was needed to assess for effect modification by partner status. Tables containing risk ratios/95% CIs were constructed for multivariate models including no interaction terms, and models that included potential effect modifiers (participant race, partner type, partner HIV status). Each of the modifiers was assessed separately in multivariate models due to limited sample sizes.

The covariance matrix of the regression parameters was input into a SAS macro to diagnose potential multicollinearity. Condition indices greater than 30, and two or more variables where the variance decomposition proportions (VDP) are greater than 0.5 indicate a potential collinearity problem.[185] According to the diagnostics, no issue of collinearity was present. Only the covariates making up interaction terms posed a potential problem (though these covariates could not be excluded from the model since they were essential to answering our research question). All analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC).

Regression Analyses – Motivational Hypothesis (Partner Status Awareness)

All of the same procedures as described above were employed for the partner status awareness outcome. The final multivariate model included the following variables: perceived risk (exposure), individual-level covariates (age, race, education, HIV knowledge), dyadic

covariates (partner type, race). Partner HIV status was not included as a control variable/effect modifier since it is a direct descendant of the outcome.

Effect Modification

Effect modification was evaluated on both on the additive and multiplicative scale. Assessing effect modification on the additive scale provides important information on the potential public health impact of targeting specific groups with interventions.[186] For example, if the effect of perceived risk on CAI were greater in one group compared to another (on the additive scale), this would identify the group for which an intervention might have a greater impact in reducing levels of CAI.[186] Evaluating effect modification on the multiplicative scale provides evidence supporting etiologic (causal) pathways between the exposure and outcome.[186]

The relative excess risk due to interaction (RERI) was used as a measure of additive interaction.[186] This measure does not provide any information on the magnitude of the additive interaction, only the direction.[186] A positive value of RERI would indicate that an intervention targeting the exposed group would have a greater impact in preventing the outcome compared to the unexposed group (and vice versa).

$$\mathbf{RERI_{11} = RR_{11} - RR_{10} - RR_{01} + 1}$$

Confidence intervals (95%) for RERI were estimated using the delta method.[187] The formula below provides the standard error needed to calculate the 95% CIs for RERI.

$$\mathbf{RERI(SE) = \sqrt{[(RR_{11}^{\,2} * Var(\beta_{11})) + (RR_{10}^{\,2} * Var(\beta_{10})) + (RR_{01}^{\,2} * Var(\beta_{01})) + (2*RR_{11}*RR_{10}*Cov(\beta_{11}, \beta_{10})) + (2*RR_{11}*RR_{01}*Cov(\beta_{11}, \beta_{01})) + (2*RR_{10}*RR_{01}*Cov(\beta_{10}, \beta_{01}))]}}$$

Values for RERI and their respective 95% CIs were estimated using an Excel spreadsheet (all inputs were obtained from SAS). The confidence intervals were estimated using covariance

estimates from the empirical correlation matrix. Measures for multiplicative interaction (including 95% CIs) were calculated in SAS using the formula below. A value greater than 1 would indicate positive interaction and a value less than 1 would indicate negative interaction on the multiplicative scale.

$$\frac{\boldsymbol{RR_{11}}}{\boldsymbol{RR_{10} * RR_{01}}}$$

Tables including risk ratios and 95% CIs were included for each combination of the latent exposure and effect modifier compared to a common referent group. Effect estimates within each strata of the effect modifier were also included. See *Appendix B* for an example of the RERI calculations.

The risk of CAI (%) along with 95% CIs for study covariates were obtained from a multivariate, no interaction model. Each effect estimate represents the risk of CAI given all other study covariates are set to the lowest risk category. Categories with the lowest risk for CAI were chosen as the referent group in analyses evaluating the presence of effect modification.

RESULTS

Reflective Hypothesis

Younger participants were more likely to be classified as low risk perceivers (Class 1) or status-derived perceivers (Class 3) compared to older participants (Table 3.2). Black participants were over two times more likely to be classified as low risk perceivers compared to White participants. Those with a high-school equivalent (or lower) level of education were more likely to be classified as Class 1, Class 3, and Class 4 risk perceivers compared to more educated participants. None of the four risk perception typologies was associated with the any CAI outcome. Participants who previously had sex with a HIV-positive partner were less likely to have their perceived risk influenced predominantly by their partner's HIV status (Class 3), and those who had sex with a status unknown partner were less likely to be classified as low risk perceivers (Class 1).

Table 3.2. Reflective Hypothesis: Adjusted Associations between Perceived Risk Typologies and Past Sexual Behaviors (N = 473)

	Low Perceived Risk (Class 1)		**Status-derived Perception (Class 3)**		**Fully Informed Perception (Class 4)**	
	OR	95% CI	OR	95% CI	OR	95% CI
Total	N=39	8.3%	N=153	32.4%	N=134	28.3%
Individual-level Factors						
Age: 18-29 *	2.25	0.85, 5.93	2.13	1.23, 3.68	1.28	0.76, 2.15
Black vs. White	2.34	1.01, 5.40	1.06	0.64, 1.78	1.00	0.59, 1.68
≤High School vs. ≥College *	6.10	2.27, 16.35	2.79	1.23, 6.35	2.26	0.94, 5.45
Low HIV Knowledge	1.18	0.52, 2.65	1.23	0.75, 2.02	0.74	0.45, 1.22
Used drugs in past 12 mo.	1.58	0.71, 3.54	1.36	0.83, 2.24	1.03	0.63, 1.71
Any CAI [1]	0.87	0.37, 2.03	0.82	0.47, 1.41	1.18	0.67, 2.07
Dyadic Factors						
Sex with any main partner [1]	1.07	0.45, 2.58	0.84	0.50, 1.43	0.71	0.42, 1.19
Sex with any HIV+ partner [1]	0.70	0.20, 2.44	0.27	0.10, 0.71	0.65	0.32, 1.34
Sex with any HIV? partner [1] *	0.36	0.16, 0.81	0.64	0.39, 1.06	1.25	0.75, 2.08
Sex with any HIV- partner [1]	0.59	0.19, 1.83	1.18	0.54, 2.60	0.87	0.43, 1.76

Class 2 (condom-derived risk) is the referent group (N = 147, 31.1%).

CAI = condomless anal intercourse
PROC LOGISTIC used to estimate ORs/95% CI.
Odds ratios are adjusted for all covariates included in the table.
* Wald chi-square p-value < 0.05
[1] Covariates constructed from a combination of baseline partner-level and participant-level data. All sexual risk behaviors refer to sex with male partners in the 6 months prior to baseline. Comparison group is any vs. none (for example: sex with at least one main partner vs. sex with no main partner).

Motivational Hypothesis – CAI

No Interaction Model for Partner-level CAI

The longitudinal, partner-level measure of CAI was not associated with any of the perceived risk typologies (Table 3.3). Black participants were less likely to report CAI compared to White participants. Participants who had sex with a main partner were two times more likely to engage in CAI compared to those reporting sex with a casual partner. Participant age, education, HIV knowledge, and the partner's HIV status was not associated with CAI at follow-up.

In separate, independent models, the following categories were found to have the lowest risk of CAI: Class 1 participants, young, Black, had a high school or lower level of education, had a high level of HIV knowledge, those who reported sex with a casual partner, and those who reported sex with a HIV-positive partner (Figure 3.4).

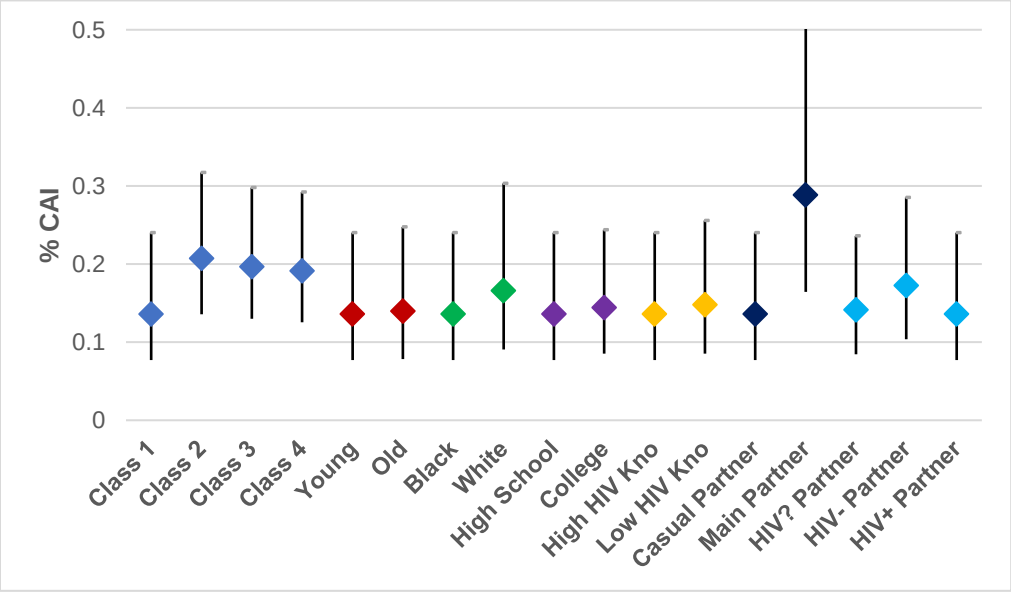
Table 3.3. Motivational Hypothesis: Adjusted Associations between Perceived Risk Typologies and Partner-Level CAI (N = 473/2,471)

	CAI	
	RR	95% CI
Participant-level Perceived Risk		
Condom-derived perception	1.53	0.98, 2.38
Status-derived perception	1.45	0.93, 2.26
Fully informed perception	1.41	0.89, 2.22
Individual-level Factors		
Age: 18-29	0.98	0.83, 1.15
Black vs. White *	0.82	0.69, 0.97
≤High School vs. ≥College	0.94	0.73, 1.22
Low HIV Knowledge	1.09	0.93, 1.27

Dyadic Factors		
Main partner *	2.12	1.86, 2.41
HIV- vs. HIV+ partner *	1.04	0.76, 1.42
HIV? vs. HIV+ partner *	1.27	0.92, 1.74

CAI = condomless anal intercourse
Class 1 (low risk perceivers) is the referent group (N = 39, 8.2%).
Ŧ 284 (11.5%) missing values for CAI outcome, 354 (14.3%) missing values for any covariate included in the model.
PROC GENMOD used to estimate adjusted RRs/95% CI for binary partner-level dependent outcome (log poisson distribution; exchangeable covariance structure).
Odds ratios are adjusted for all covariates included in the table.
* Score chi-square p-value < 0.05

Figure 3.4. Adjusted Risk of CAI (%) by Study Covariates (N = 473/2,471)



Effect Modification by Partner Type (CAI)

Table 3.4. Effect of Perceived Risk Typologies on CAI by Partner Type (N = 473/2,471)

	Perceived Risk (LCA)				**RR w/in strata of partner type**		
	Low perceived risk (class 1)	**Condom-derived perception (class 2)**	**Status-derived perception (class 3)**	**Fully informed perception (class 4)**	**Class 2 vs. Class 1**	**Class 3 vs. Class 1**	**Class 4 vs. Class 1**
	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)
Main Partner	2.25 (1.16, 4.39)*	3.38 (1.82, 6.26)*	3.19 (1.72, 5.92)*	2.97 (1.59, 5.54)*	1.50 (0.91, 2.48)	1.42 (0.86, 2.34)	1.32 (0.79, 2.19)
Casual Partner	1.0 (referent)	1.56 (0.83, 2.92)	1.48 (0.79, 2.77)	1.49 (0.79, 2.80)	1.56 (0.83, 2.92)	1.48 (0.79, 2.77)	1.49 (0.79, 2.80)

Ŧ 284 (11.5%) missing values for CAI outcome, 354 (14.3%) missing values for any covariate included in the model.
PROC GENMOD used to estimate adjusted RRs/95% CI for binary partner-level dependent outcome (log poisson distribution; exchangeable covariance structure).
Adjusted by all variables included in the no interaction model (Table 3.3).
Class 1 is the referent group for risk ratios within strata of partner type. Example: Class 2 vs. Class 1 within strata of main partners calculates the risk ratio of Class 2, main partners vs. Class 1, main partners.
* Chi-square p-value < 0.05

Table 3.5. Measures of Interaction by Partner Type (CAI)

	RERI	**Multiplicative Interaction**
	Value (95% CI)	Value (95% CI)
Class 2 vs. Class 1	0.57 (-8.02, 9.15)	0.96 (0.48, 1.94)
Class 3 vs. Class 1	0.46 (-7.44, 8.36)	0.96 (0.48, 1.93)
Class 4 vs. Class 1	0.23 (-7.02, 7.48)	0.89 (0.44, 1.79)

* Chi-square p-value < 0.05
Class 2 vs. Class 1: compares whether the effect of condom-derived risk perception (Class 2) vs. low perceived risk (Class 1) on CAI differs between main and casual partners.

Regardless of class, participants who reported sex with a main partner were much more likely to engage in CAI during follow-up when compared to the referent group (Class 1 participants who reported sex with a casual partner). The risk of CAI was highest for participants whose perceived risk was largely dependent on condom use (Class 2) for those reporting sex with main or casual partners (Table 3.4). When comparing the effect of perceived risk on CAI across strata of partner type, we observed no difference in the effect of perceived risk on CAI. There was no evidence of statistical interaction (either additive or multiplicative) by partner type (Table 3.5).

Effect Modification by Participant Race (CAI)

Table 3.6. Effect of Perceived Risk Typologies on CAI by Participant Race (N = 473/2,471)

	Perceived Risk (LCA)				**RR w/in strata of race**		
	Low perceived risk (class 1)	**Condom-derived perception (class 2)**	**Status-derived perception (class 3)**	**Fully informed perception (class 4)**	**Class 2 vs. Class 1**	**Class 3 vs. Class 1**	**Class 4 vs. Class 1**
	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)
White	3.77 (1.67, 8.51)*	3.36 (1.71, 6.61)*	3.17 (1.61, 6.24)*	3.01 (1.53, 5.95)*	0.89 (0.54, 1.48)	0.84 (0.51, 1.40)	0.80 (0.48, 1.34)
Black	1.0 (referent)	2.85 (1.42, 5.73)*	2.71 (1.36, 5.40)*	2.76 (1.36, 5.61)*	2.85 (1.42, 5.73)*	2.71 (1.36, 5.40)*	2.76 (1.36, 5.61)*

Ŧ 284 (11.5%) missing values for CAI outcome, 354 (14.3%) missing values for any covariate included in the model.
PROC GENMOD used to estimate adjusted RRs/95% CI for binary partner-level dependent outcome (log poisson distribution; exchangeable covariance structure).
Adjusted by all variables included in the no interaction model (Table 3.3).
Class 1 is the referent group for risk ratios within strata of participant race. Example: Class 2 vs. Class 1 within strata of White participants calculates the risk ratio of Class 2, White participants vs. Class 1, White participants.
* Chi-square p-value < 0.05

Table 3.7. Measures of Interaction by Participant Race (CAI)

	RERI	**Multiplicative Interaction**
	Value (95% CI)	Value (95% CI)
Class 2 vs. Class 1	-2.26 (-18.16, 13.64)	0.31 (0.13, 0.74)*
Class 3 vs. Class 1	-2.31 (-17.55, 12.93)	0.31 (0.13, 0.73)*
Class 4 vs. Class 1	-2.52 (-17.58, 12.54)	0.29 (0.12, 0.69)*

* Chi-square p-value < 0.05
Class 2 vs. Class 1: compares whether the effect of condom-derived risk perception (Class 2) vs. low perceived risk (Class 1) on CAI differs between White and Black participants.

Across all classes of risk perception, White participants were more likely to engage in CAI compared to Black participants (Table 3.6). Among White participants, those with low perceived risk (Class 1), and among Black participants, those with condom-derived perception (Class 2) were most likely to engage in CAI. Within strata of White participants, the effect of perceived risk on CAI was similar (null) across all classes, indicating that risk perception had little impact on behaviors. Within strata of Black participants, condom-derived (Class 2), status-derived (Class 3), and fully informed (Class 4) risk perceivers were more likely to engage in CAI compared to low risk perceivers (Class 1). While there is no evidence of additive interaction by participant race, we observed differences by participant race on the multiplicative scale for all three comparisons (Table 3.7).

Effect Modification by Partner HIV Status (CAI)

Table 3.8. Effect of Perceived Risk Typologies on CAI by Partner HIV Status (N = 473/2,471)

	Perceived Risk (LCA)				**RR w/in strata of partner HIV status**		
	Low perceived risk (class 1)	**Condom-derived perception (class 2)**	**Status-derived perception (class 3)**	**Fully informed perception (class 4)**	**Class 2 vs. Class 1**	**Class 3 vs. Class 1**	**Class 4 vs. Class 1**
	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)
HIV?	0.38 (0.11, 1.31)	0.75 (0.36, 1.55)	0.98 (0.48, 2.01)	0.90 (0.44, 1.85)	1.98 (0.62, 6.32)	2.60 (0.82, 8.25)	2.39 (0.75, 7.58)
HIV-	0.73 (0.32, 1.66)	1.15 (0.58, 2.26)	1.04 (0.53, 2.05)	1.01 (0.51, 2.00)	1.58 (0.95, 2.64)	1.44 (0.86, 2.40)	1.39 (0.83, 2.34)
HIV+	1.00 (referent)	1.09 (0.51, 2.34)	0.45 (0.12, 1.62)	0.74 (0.29, 1.91)	1.09 (0.51, 2.34)	0.45 (0.12, 1.62)	0.74 (0.29, 1.91)

Ŧ 284 (11.5%) missing values for CAI outcome, 354 (14.3%) missing values for any covariate included in the model.
PROC GENMOD used to estimate adjusted RRs/95% CI for binary partner-level dependent outcome (log poisson distribution; exchangeable covariance structure).
Adjusted by all variables included in the no interaction model (Table 3.3).
Class 1 is the referent group for risk ratios within strata of partner HIV status. Example: Class 2 vs. Class 1 within strata of HIV status unknown partners calculates the risk ratio of Class 2, HIV? partners vs. Class 1, HIV? partners.
* Chi-square p-value < 0.05

Table 3.9. Measures of Interaction by Partner HIV Status (CAI)

	RERI	**Multiplicative Interaction**
	Value (95% CI)	Value (95% CI)
Class 2 vs. Class 1 (HIV? vs. HIV+)	0.28 (-1.23, 1.79)	1.81 (0.49, 6.70)
Class 2 vs. Class 1 (HIV- vs. HIV+)	0.33 (-1.76, 2.42)	1.45 (0.58, 3.63)
Class 3 vs. Class 1 (HIV? vs. HIV+)	1.15 (-0.04, 2.36)	5.73 (1.15, 29.28)*
Class 3 vs. Class 1 (HIV- vs. HIV+)	0.86 (-0.60, 2.34)	3.17 (0.80, 12.73)
Class 4 vs. Class 1 (HIV? vs. HIV+)	0.78 (-0.53, 2.10)	3.20 (0.79, 13.20)
Class 4 vs. Class 1 (HIV- vs. HIV+)	0.54 (-1.11, 2.20)	1.87 (0.64, 5.51)

* Chi-square p-value < 0.05
Class 2 vs. Class 1 (HIV? vs. HIV+): compares whether the effect of condom-derived risk perception (Class 2) vs. low perceived risk (Class 1) on CAI differs between HIV status unknown partners and HIV-positive partners.

All effect estimates were statistically insignificant across perceived risk typologies and partner HIV statuses (Table 3.8). Although there is no evidence of additive interaction by partner HIV status, the effect of Class 3 vs. Class 1 on CAI differed between status unknown and HIV-positive partners on the multiplicative scale (Table 3.9). Specifically, Class 3 participants were more likely to engage in CAI with status unknown partners, but less likely to engage in CAI with HIV-positive partners.

Motivational Hypothesis – Partner HIV Status Awareness

No-Interaction Model for Partner Status Awareness

Low risk perceivers (Class 1) were 17% more likely to be aware of their partner's HIV status compared to fully informed risk perceivers (Class 4) (Table 3.10). Black participants were less likely to be aware of their partner's serostatus compared to White participants. Those who reported sex with main partners were more likely to be aware of their partner's status compared to participants who reported sex with casual partners. There was no difference in partner status awareness by participant age, education, HIV knowledge, and partner race.

Table 3.10. Motivational Hypothesis: Adjusted Associations between Perceived Risk Typologies and Partner Status Awareness (N = 472/2,459)

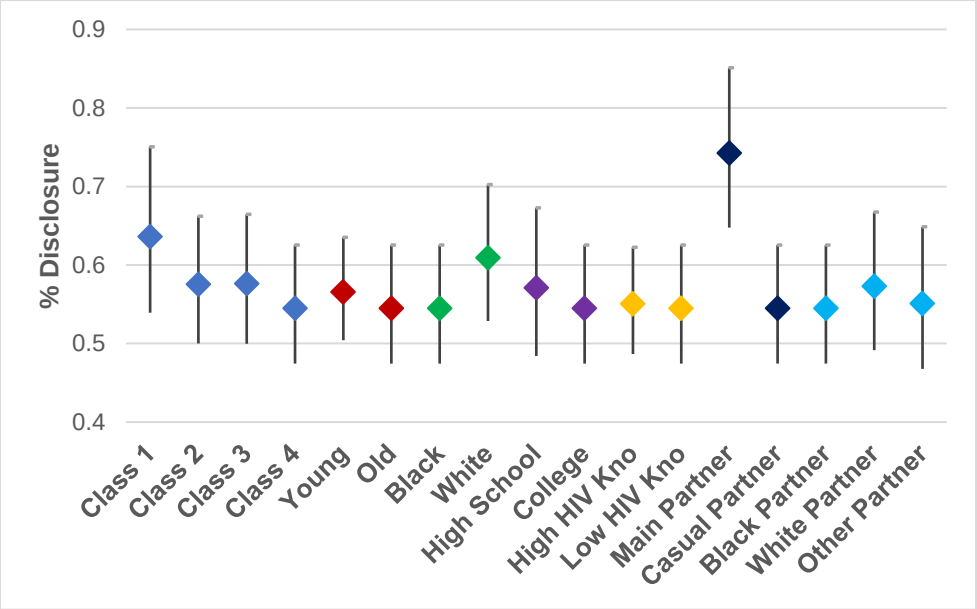
	Status Awareness	
	RR	95% CI
Participant-level Perceived Risk		
Low perceived risk	1.17	1.02, 1.34
Condom-derived perception	1.06	0.95, 1.17
Status-derived perception	1.06	0.95, 1.17
Individual-level Factors		
Age: 18-29	1.04	0.95, 1.14
Black vs. White *	0.89	0.80, 1.00
≤High School vs. ≥College	1.05	0.93, 1.19
Low HIV Knowledge	0.99	0.91, 1.07
Dyadic Factors		
Main partner *	1.36	1.28, 1.45
Black vs. White partner	0.95	0.87, 1.04

Other vs. White partner	0.96	0.89, 1.04

Class 4 (fully-informed risk perceivers) is the referent group (N = 134, 28.3%).
Ŧ 102 (4.2%) missing values for serodiscussion outcome, 164 (6.7%) missing values for any covariate included in the model.
PROC GENMOD used to estimate adjusted RRs/95% CI for binary partner-level dependent outcome (log poisson distribution; exchangeable covariance structure).
Odds ratios are adjusted for all covariates included in the table.
* Score chi-square p-value < 0.05

In separate, independent models, the following categories were found to have the lowest rates of partner HIV status awareness: Class 4 participants, participants who were older, Black, had a college or higher level of education, had a low level of HIV knowledge, those who reported sex with a casual partner, and those who reported sex with a Black partner (Figure 3.5).

Figure 3.5. Adjusted Risk of Partner Status Awareness (%) by Study Covariates (N = 472/2,459)



Effect Modification by Partner Type (Partner Status Awareness)

Table 3.11. Effect of Perceived Risk Typologies on Partner Status Awareness by Partner Type (N = 472/2,459)

	Perceived Risk (LCA)				**RR w/in strata of partner type**		
	Fully Informed Perception (class 4)	**Low perceived risk (class 1)**	**Condom-derived perception (class 2)**	**Status-derived perception (class 3)**	**Class 1 vs. Class 4**	**Class 2 vs. Class 4**	**Class 3 vs. Class 4**
	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)
Main Partner	1.48 (1.32, 1.65)*	1.51 (1.26, 1.80)*	1.44 (1.26, 1.63)*	1.47 (1.30, 1.65)*	1.02 (0.87, 1.21)	0.97 (0.87, 1.09)	0.99 (0.90, 1.10)
Casual Partner	1.00 (referent)	1.26 (1.04, 1.51)*	1.09 (0.96, 1.24)	1.09 (0.95, 1.25)	1.26 (1.04, 1.51)*	1.09 (0.96, 1.24)	1.09 (0.95, 1.25)

Ŧ 102 (4.2%) missing values for serodiscussion outcome, 164 (6.7%) missing values for any covariate included in the model.
PROC GENMOD used to estimate adjusted RRs/95% CI for binary partner-level dependent outcome (log poisson distribution; exchangeable covariance structure).
Adjusted by all variables included in the no interaction model (Table 3.10).
Class 4 is the referent group for risk ratios within strata of partner HIV status. Example: Class 1 vs. Class 4 within strata of main partners calculates the risk ratio of Class 1, main partners vs. Class 4, main partners.
* Chi-square p-value < 0.05

Table 3.12. Measures of Interaction by Partner Type (Partner Status Awareness)

	RERI	**Multiplicative Interaction**
	Value (95% CI)	Value (95% CI)
Class 1 vs. Class 4	-0.23 (-0.87, 0.42)	0.81 (0.64, 1.03)
Class 2 vs. Class 4	-0.13 (-0.62, 0.36)	0.89 (0.76, 1.05)
Class 3 vs. Class 4	-0.10 (-0.59, 0.39)	0.91 (0.78, 1.06)

* Chi-square p-value < 0.05
Class 1 vs. Class 4: compares whether the effect of low perceived risk (Class 1) vs. fully-informed perceived risk (Class 4) on disclosure differs between main and casual partners.

Across all four classes of perceived risk, participants who had sex with main partners were more likely to be aware of their partner's HIV status compared to those who reported sex with casual partners (Table 3.11). Within strata of main partners, the (null) effect of perceived risk on partner status awareness was similar across all classes, indicating little to no impact of perceived risk on partner status awareness. Within strata of casual partners, only low risk perceivers (Class 1) had elevated rates of partner status awareness compared to the referent group. There was no evidence of statistical interaction either on the additive or multiplicative scale (Table 3.12).

Effect Modification by Participant Race (Partner Status Awareness)

Table 3.13. Effect of Perceived Risk Typologies on Partner Status Awareness by Participant Race (N = 472/2,459)

	Perceived Risk (LCA)				**RR w/in strata of race**		
	Fully Informed Perception (class 4)	**Low perceived risk (class 1)**	**Condom-derived perception (class 2)**	**Status-derived perception (class 3)**	**Class 1 vs. Class 4**	**Class 2 vs. Class 4**	**Class 3 vs. Class 4**
	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)
White	0.99 (0.84, 1.17)	1.35 (1.16, 1.58)*	1.10 (0.94, 1.30)	1.12 (0.95, 1.32)	1.36 (1.20, 1.55)*	1.11 (0.98, 1.26)	1.13 (0.99, 1.28)
Black	1.00	1.02 (0.82, 1.26)	0.97 (0.80, 1.17)	0.96 (0.81, 1.14)	1.02 (0.82, 1.26)	0.97 (0.80, 1.17)	0.96 (0.81, 1.14)

Ŧ 102 (4.2%) missing values for serodiscussion outcome, 164 (6.7%) missing values for any covariate included in the model.
PROC GENMOD used to estimate adjusted RRs/95% CI for binary partner-level dependent outcome (log poisson distribution; exchangeable covariance structure).
Adjusted by all variables included in the no interaction model (Table 3.10).
Class 4 is the referent group for risk ratios within strata of participant race. Example: Class 1 vs. Class 4 within strata of White calculates the risk ratio of Class 1, White participants vs. Class 4, White participants.
* Chi-square p-value < 0.05

Table 3.14. Measures of Interaction by Participant Race (Partner Status Awareness)

	RERI	**Multiplicative Interaction**
	Value (95% CI)	Value (95% CI)
Class 1 vs. Class 4	0.34 (-0.18, 0.87)	1.34 (1.05, 1.72)*
Class 2 vs. Class 4	0.14 (-0.30, 0.59)	1.15 (0.91, 1.44)
Class 3 vs. Class 4	0.17 (-0.27, 0.61)	1.18 (0.95, 1.46)

* Chi-square p-value < 0.05
Class 1 vs. Class 4: compares whether the effect of low perceived risk (Class 1) vs. fully-informed perceived risk (Class 4) on disclosure differs between White and Black participants.

White, low risk perceivers were more likely to know their partner's serostatus compared to Black, fully informed risk perceivers (Table 3.13). Among White participants, those with low perceived risk were most likely to be aware of their partner's HIV status. Partner status awareness was similar across all typologies of perceived risk among Black participants. We found evidence for statistical interaction on the multiplicative scale when comparing Class 1 to Class 4 participants (Table 3.14). Low risk perception had a positive effect (higher rates of status awareness for Class 1 vs. Class 4 participants) on partner status awareness among White participants, but had no effect among Black participants.

DISCUSSION

Summary of Results

Reflective Hypothesis

Overall, we found no evidence that past CAI had any influence on participants' HIV risk perception, which was consistent to what was found in Aim 1. However, participants' choice of partners seemed to correlate with their perception of risk. As expected, participants who valued the HIV status of their partner when thinking about their risk of infection (Class 3) were less likely to report prior sex with serodiscordant (HIV-positive) partners. Additionally, men who believed they were at low risk for infection (Class 1) were less likely to have had sex with a status unknown partner. Both these results were found in unadjusted analyses from Aim 1. However, we controlled for a variety of multi-level factors in Aim 2. Although previous CAI may not have impacted participants' perception of risk, results from this aim provide some evidence supporting the hypothesis that past behaviors inform current perception of risk.

Previous studies evaluating the relationship between perceived HIV risk and sexual behaviors were cross-sectional in design, making them suitable for testing the validity of the reflective hypothesis. However, these studies utilized an ordinal measure of perceived risk, making it difficult to compare results. As a whole, results from previous were contradictory. Among the three studies that were specifically designed to evaluate the reflective hypothesis, one found null results, while the other two found weak evidence supporting the reflective hypothesis.[79,132,149] Another study found that lower frequency of prior HIV testing (which may serve as a proxy for past high risk sexual behaviors) was correlated with a low perception of risk.[188]

Motivational Hypothesis - CAI

Overall, Black participants were less likely to report engaging in CAI compared to White participants, confirming results from previous literature.[8,10-13,16,110] Among Black participants, low risk perceivers (Class 1) were less likely to report CAI at follow-up compared to the other classes, refuting the motivational hypothesis that those with low levels of perceived risk engage in riskier behaviors in the future. However, the risk ratios for Black, non-low risk perceivers (Classes 2, 3, and 4) were similar in magnitude, suggesting that fewer typologies of risk perception may be relevant for young Black MSM. A high/low categorization of perceived risk may be just as good of an indicator or predictor of risky sexual behaviors compared to a latent categorization of risk perception. Even though White participants were more likely to engage in CAI compared to Black participants, the perceived risk typologies did not seem to have an impact on predicting CAI in this population. No study has looked at the effect of perceived risk on sexual behaviors by race.

In the reflective results, we saw that low risk perceivers were less likely to report any previous sex with status unknown partners. Although these results came from independent models (we do not know if the Black low risk perceivers that engaged in less CAI at follow-up, were the same participants who were less likely to report any sex with status unknown partners at baseline), they point towards a unique typology that does not follow the reciprocal relationship outlined in health behavior models. These individuals with a low risk perception may continually practice safe behaviors both at baseline and at follow-up. One study found that HIV-negative and status unaware MSM with a low level of perceived risk were more likely to practice protective behaviors (e.g., frequently test for HIV).[189]

Participants who placed the most emphasis on condom use (Class 2) when evaluating their perception of risk did not have lower rates of CAI compared to other classes. These participants believed that condom use decreased their risk for infection, yet this belief did not translate into appropriate action (practicing safer sex).

Rates of CAI were higher among those reporting sex with main vs. casual partners, confirming results from prior studies.[152,172-174] We found no evidence that the effect of perceived risk on future behaviors differed by partner type, though one study found that participants with high levels of perceived risk *intended* to use condoms more consistently in the future, more-so with main compared to casual partners.[132] These findings are not surprising because risk perception may have little to no role in influencing behaviors within main partnerships, where trust and intimacy often dictate risk.[147] However, we expected the typologies of perceived risk to have more of an influence on sexual behaviors within casual partnerships.

Participants whose perceived risk was largely influenced by their partner's HIV status (Class 3) were respectively more and less likely to engage in CAI with status unknown and HIV-positive partners. The latter association reinforces participants' beliefs about their risk for HIV infection: that those who are most worried about their partner's HIV status will take action to minimize risky behaviors with HIV-positive partners. This coincides with findings from the reflective hypothesis, where those who reported previous sex with HIV-positive partners were unlikely to believe that partner status played an important role in their perception of risk. Although these (Class 3) participants may go out of their way to avoid sexual encounters with partner known to be living with HIV infection, they place themselves at substantial risk by engaging in CAI with partners of unknown HIV status.

Motivational Hypothesis – Partner Status Awareness

Overall, low risk perceivers (Class 1) were more likely to be aware of their partner's HIV status compared to Class 4 participants. This association was present in White MSM, but absent among Black MSM, who had similar rates of partner status awareness across all typologies of perceived risk. Similar to previous studies, we found that White MSM had higher rates, and Black MSM had lower rates of partner status awareness.[190-192] Both groups may be compensating for the riskiness of one act (e.g., high rates of CAI among White MSM, low rates of status awareness among Black MSM), by engaging in protective behaviors (e.g., high rates of status awareness among White MSM, low rates of CAI among Black MSM). We do not know whether Black (or White) MSM were differentially unaware of their partner's serostatus in partnerships where condoms weren't used, compared to partnerships in which condoms were used. However, one study found that rates of disclosure were lower among Black MSM who engaged in CAI compared to White MSM.[193]

Participants who reported sex with main partners were more likely to be aware of their partner's HIV status compared to those who had sex with casual partners, supporting findings from the literature.[81,194] Among those reporting sex with casual partners, low risk perceivers (Class 1) had higher rates of partner status awareness. These results provide further evidence of a low risk perception typology in which protective behaviors (e.g., less CAI for Black MSM; greater awareness of partner serostatus overall, among White MSM, and among participants reporting sex with casual partners) are practiced for a sustained amount of time (at baseline and at follow-up). Because our models (and results) were independent of one another, we would need to conduct rigorous analyses incorporating repeated outcome measures to validate a continual causal framework for this risk perception typology.

Strengths & Limitations

Strengths

One of the main strengths of this study is the longitudinal design, which allowed us to properly assess the temporal relationship between perceived risk and behaviors. Previous studies predominantly used a cross-sectional design to evaluate the motivational hypothesis, which contributed to inconsistent findings. This study also allowed us to concurrently assess the reflective and motivational hypotheses within the same study population, giving us a better idea of the continual mechanism in which behaviors affect perceived risk and vice-versa. Testing these hypotheses in separate studies, with different study populations, may produce results that cannot be compared or combined, making it more difficult to validate a unified causal framework.

Another strength of this study was its novel conceptualization of HIV risk perception. Latent class analysis allowed us to identify subgroups of participants with unique and specific patterns of perceived risk. Instead of utilizing a traditional, ordinal (high/low) categorization of perceived risk that's used in most studies, the latent measure, which incorporated conditional, partner-specific questions, identified the factors MSM value most when thinking about their own risk of HIV infection.

Because perception of risk can vary from one partner to the next (depending on dyadic characteristics specific to the partner), conducting a individual-level analysis that combines the potentially different effects across all partners (within the same participant), might obscure the relationship between perceived risk and behaviors. Few studies have utilized partner-level (dyadic) data to asses this relationship. The longitudinal study design and collection of partner-specific data allowed us to conduct a partner-level analysis, control for important dyadic-level

confounders, and assess for the presence of effect modification by individual-level (participant race) and dyadic factors (partner type, partner HIV status).

Limitations

The primary limitation of this study is the potential for misclassification of the exposure and the outcome. Latent class analysis assigns participants to specific classes based on their highest posterior probability of assignment, and as such, an individual's true class membership is never known.[156] In this study, we treated the class assignments as absolute. To account for uncertainty of assignments, multiple imputation techniques (using multiple assignment draws) can be used to obtain adjusted effect estimates.[156] If any misclassification of the latent perceived risk measure exists, we expect the bias to be non-differential with respect to our outcomes, producing a conservative estimate of the association between perceived risk and behaviors.

All study covariates, including outcomes (CAI, partner status awareness) were obtained via self-report. HIV-related risk behaviors are often prone to social desirability bias due to the stigma associated with these behaviors, and the populations engaged in them.[84,85,169] Sexual identity, partner gender, the number of sexual partners, and sex work were just some of the self-reported behaviors that were found in studies to be subject to misclassification.[84,85] Two studies found differential rates of misclassification of drug use and HIV status awareness by race: Black MSM were more likely to misclassify themselves as HIV-negative or non-drug users compared to White MSM.[169,195] Another study found that the level of discordant reports of CAI were much higher in Black partnerships compared to White partnerships.[196] A significant degree of misclassification by race may be able to explain the paradox between higher rates of HIV infection, and lower levels of reported risk behaviors among Black MSM.[17] In this study, we found differential rates of CAI and partner status awareness by race, and differential effects of

perceived risk typologies on behaviors by race. Unfortunately, we do not know whether these differences are real or a result of misclassification. If Black MSM were more likely to underreport CAI compared to White MSM, we'd expect that our results would be closer the null, potentially eliminating any differential effects by race. Future studies should incorporate the use of accurate behavioral measures (e.g., biomarkers) to replace self-reported measures that are prone to misclassification.[17]

This study utilized a global, participant-level measure of perceived risk, which assumes that the perceived risk of infection is the same for all sexual partners of the same individual. However, perceived risk may vary from one partner to the next, and even within the same partner over time. As such, studies have advocated for the use of partner-specific measures of perceived risk.[79,147] The potential bias associated with the use of a global measure may have been minimized since we were able to control for some dyadic factors (partner type, partner HIV status) known to affect HIV risk perception.

The 16 separate perceived risk questions (used to construct the latent class covariate) may be misinterpreted by participants more as a measure of their knowledge regarding HIV transmission risks, rather than their beliefs regarding the likelihood of becoming infected with HIV.[145] Even though these questions specifically asked participants to rate how risky these sexual acts were to *them*, they may answer these questions not based on their own experiences, preferences, or beliefs, but through their general knowledge of HIV transmission risks. Ultimately, these questions don't actually capture the perceived riskiness of scenarios that participants have or are willing to engage in. For instance, an individual may never engage in certain risky behaviors (e.g., receptive anal intercourse with a HIV-positive partner), but may rate that activity as very risky. In contrast, low risk perceivers (Class 1) may rate all sexual

scenarios as low risk activities because they have not and don't ever plan to engage in these types of behaviors (which is reflected in both their past and future behaviors). We controlled for HIV knowledge in our models to differentiate perceived risk from a general knowledge of HIV transmission.

Longitudinal measures of CAI and partner status awareness outcomes were utilized to evaluate the motivational hypothesis. However, outcomes measuring changes in behavior may have been more appropriate for this study, since baseline behaviors might be a marker for propensity to engage in CAI. A man who reports CAI at baseline and at follow-up (with the same partner) is behaviorally different from another who has protected sex at baseline, but engages in CAI at follow-up with the same partner. In our analyses, these two individuals would be treated the same way. Limiting the study population to only those partnerships with measurements at both baseline and follow-up would have severely decreased the sample size and limited the power of the study. There were only 330 partnerships (8% of all male partnerships) where CAI was reported at baseline and follow-up, and 289 partnerships (7% of all male partnerships) where partner status awareness was reported at baseline and follow-up.

Another potential study limitation is whether dyadic measures such as partner type and partner HIV status should be treated as mediators rather than confounders or effect modifiers. It is plausible that the participant's risk perception can influence their choice of partners. For example, a status-derived (Class 3) risk perceiver may pursue future HIV-negative partners, to ensure they are protected even if they were to engage in CAI with these partners. In this case, partner status would serve as a mediator of the relationship between perceived risk and behaviors. The mediator assumption only holds true if all partnerships reported during the follow-up period comprise new sexual relationships. Otherwise, perceived risk at baseline could

not have influenced their choice of partners (by partner type or partner HIV status). The study sample was comprised of already existing partnerships (reported at baseline) and "new" partnerships only reported during follow-up. It is likely that some of these "new" partners were comprised of already-existing partnerships that weren't reported at baseline (but with whom the participant had known, and had sex with previously). We are unaware what proportion of these partnerships truly represent first time sexual encounters. Therefore, we treated all partner-level (dyadic) covariates as confounders (or effect modifiers). Even if some of these covariates served as mediators, controlling for them in our analysis provides us with a conservative estimate (i.e., the direct effect) of the total effect of perceived risk on behaviors.

Although this study improved upon previous research by accounting for dyadic factors and conducting a partner-level analysis, future studies should collect data on other multi-level factors affecting both one's perception of HIV risk and their sexual behaviors. For example, structural factors such as high levels of HIV-related stigma or homophobia within the community can raise one's perceived risk for HIV infection, while at the same time, increase their practice of risky behaviors.

Public Health Importance

In this study, we assessed the relationship between typologies of perceived risk and two behavioral outcomes (CAI, partner status awareness) affecting the risk of HIV infection. These outcomes represent only a fraction of the numerous risk factors facilitating HIV transmission. HIV prevention programs should have a comprehensive understanding of the risk profile of a vulnerable individual, and identify the specific areas in which intervention can have the greatest impact in preventing infection. Because programs are resource constrained and have a limited set

of prevention tools, it becomes imperative to identify those individuals who may benefit most from available services.

Risk assessments are a common component of HIV counseling and testing (HCT) sessions.[82] However, risk assessment tools have been found to be barriers to HIV testing because they are both time-consuming and involve disclosing stigmatizing behaviors.[83] One study found that disclosed behaviors from risk assessments administered during HCT sessions were often inaccurate.[82] If we could instead, replace the cumbersome risk assessment, with a shortened tool measuring different typologies of perceived risk, we may be able to better identify populations that will likely engage in risky behaviors in the future.

Results from this study indicate that these typologies of perceived risk can be used to identify groups who are likely to engage in high risk behaviors, and who might benefit from specific prevention services. For instance, we found that status-derived risk perceivers (Class 3) were much more likely to engage in CAI with status unknown partners than they were with known HIV-positive partners. Targeting these individuals with behavioral interventions designed to promote condom use or facilitate serodiscussion with partners of unknown HIV status may decrease their risk for HIV infection.

We also identified a potentially low risk population (Class 1) consistently reporting protective behaviors at follow-up. Black, low risk perceivers reported less CAI and low risk perceivers overall, among White MSM, and with casual partners had a greater awareness of their partner's serostatus. We do not know whether these findings are legitimate or a result of differential misclassification by race. Further investigation of the multi-level factors associated with sexual behaviors of YBMSM are needed, so that they can be inform the development of risk-reduction interventions targeting this group.

Future studies need to evaluate whether this latent risk perception measure, which was constructed from a set of 16 questions conditional on sexual behaviors and dyadic partner characteristics, better predicts future HIV risk compared to an ordinal (high/low) measure of risk perception. Additional multi-level factors related to perceived risk and HIV risk behaviors should be incorporated into the future measures of perceived risk to assess whether it improves its predictive ability.

Conclusion

In this study, we identified two novel typologies of perceived risk that were correlated with both past and future behaviors, lending support to a continual causal framework. Participants who believed they were at low risk for infection (Class 1) were less likely to report sex with status unknown partners at baseline, and more likely to report protective behaviors (less sex with status unknown partners, less CAI among Black MSM, greater awareness of partner HIV status) at follow-up. Those who placed the most emphasis on their partner's HIV status when evaluating their perceived risk (Class 3) were less likely to report sex with a HIV-positive partner at baseline, and less likely to report CAI with a HIV-positive partner at follow-up. We also observed differences in the effects of these typologies on behaviors at the individual-level by race (perceived risk typologies affected CAI in Black but not White MSM, and influenced partner status awareness in White but not Black MSM) and at the dyadic-level by partner HIV status (status-derived risk perceivers were more likely to engage in CAI with status unknown partners, and less likely to report CAI with HIV-positive partners).

Previous studies have shown that despite lower prevalence of risk behaviors, Black MSM are diagnosed with HIV at much higher rates compared to White MSM.[8,10-13] Racial differences in the relationship between these perceived risk typologies and sexual risk behaviors may

provide further insight into these disparities. Future studies are needed to identify risk perception typologies that are relevant to YBMSM, and assess whether these typologies have better predictive abilities compared to ordinal measures.

Overall, there is a lack of multi-level interventions designed to reduce HIV-related risk behaviors among YBMSM. Currently, the CDC does not have any dyadic EBIs designed to reduce high risk behaviors among YBMSM. One dyadic EBI targeting Black, serodiscordant, heterosexual couples found increases in condom use following couple sessions that focused on interpersonal factors associated with sexual risk reduction, including communication, problem solving, monogamy, and negotiation skills.[299] Only one community-level intervention targeting young, mostly White MSM found reductions in CAI.[300] The intervention was carried out by a core group of young gay men and project activities included: outreach to venues frequented by young gay men to distribute condoms and deliver information on HIV risk reduction, group meetings to discuss factors associated with unsafe sex and skills-building exercises to negotiate safer sex, and the empowerment of study participants to conduct informal outreach to discuss safe sex practices with their friends.[300] There are no structural EBIs designed to reduce levels of HIV-related risk behaviors among HIV-negative YBMSM. Further research is needed to identify multi-level factors associated with HIV risk within this population.

This aim improved upon the deficiencies of previous studies by appropriately assessing the motivational hypothesis within a longitudinal design, and controlling for important dyadic (partner-level) factors related to both HIV risk perception and sexual behaviors. We identified two typologies of perceived risk, in which the conditional behaviors and dyadic characteristics that defined these typologies, matched both past and future behaviors. Further studies are needed

to confirm the existence of these typologies and their relationship to HIV risk behaviors, and ensure that these associations are not an artifact of misclassification or other forms of biases.

CHAPTER 4. IDENTIFYING MULTI-LEVEL DOMAINS RELATED TO ANTIRETROVIRAL THERAPY ACCESS AND ADHERENCE AMONG YOUNG, HIV-POSITIVE BLACK MSM IN ATLANTA, GA

INTRODUCTION

HIV Treatment as Prevention (TasP)

Not only does access and adherence to ART provide immediate health benefits including improved survival for PLWHA, it can have a profound impact on reducing HIV incidence.[198,199] Multiple studies have found that PLWHA cannot transmit HIV when they are virally suppressed.[44,88,113] Recently, the concept of treating seropositive individuals to prevent the sexual transmission of HIV has gained traction (known as treatment as prevention - TasP). Allocating prevention resources towards those infected with HIV represents a more efficient and potentially cost-effective strategy compared to prevention efforts focused on a much larger, HIV-uninfected population. One study found that the provision of early ART was cost-effective over a 5-year period ($1,800 per life-year saved), and over an entire lifetime ($5590 per life-year saved), only taking into account the health-related costs (e.g., cost of ART, cost of treating opportunistic infections and hospitalizations) of the HIV-infected individual.[301] If HIV infections averted as a result of early initiation, expanded access, or improved adherence to ART are taken into account, the cost-effectiveness of TasP becomes even greater.[302]

Multi-Level Factors Associated with ART Access and Adherence among PLWHA

Although most prevention interventions focus on reducing individual-level behaviors among those without HIV, these interventions have not been shown to reduce HIV incidence.[30] Interventions delivered to PLWHA are much more amenable to impacting transmission risks at

multiple levels (individual, dyadic, structural). Optimal adherence to ART resulting in viral suppression, is key to limiting HIV transmission and disease progression.[197] Once diagnosed, PLWHA must successfully navigate their way past structural and environmental barriers to gain access and adhere to ART. Previous studies have found that unstable housing (structural factor) can contribute to poor adherence by not providing a safe and secure location for PLWHA to store their medications. [200,201] Consistent with Maslow's hierarchy of needs theory, PLWHA will often prioritize securing basic needs (e.g., housing, employment, addressing food insecurities) before focusing on their own health.[101,200,201,205,206] The involuntary movement from one health plan or system of coverage to another (known as "churning") can lead to a loss of retention, and disruptions in access to vital care services and medications.[239-241]

Dyadic factors such as social support can also play an important role in affecting access and adherence to ART. Interactions with HIV-positive individuals leading healthy and successful lives can motivate others to remain adherent to their treatment regimens.[56] Members of their social support network can provide PLWHA with material support such as transportation to their medical appointments or financial help to obtain housing.[55,56]

Lack of Multi-Level HIV Prevention Interventions among HIV-Positive YBMSM

Not only are Black MSM more likely to be diagnosed with HIV, Black MSM living with HIV are also more likely to have worse treatment outcomes (e.g., inconsistent HIV care, non-adherence to ART, unsuppressed viral loads, etc.) when compared with White, seropositive MSM.[15,104-106] Similarly, younger PLWHA and corresponding MSM subpopulations are at greater risk of treatment cascade failures.[104,107-111]

Racial differences in multi-level factors that increase the risk of HIV transmission may help to explain Black-White disparities in HIV infection. Multi-level and combination HIV

prevention strategies have the potential to reach a greater number of people, and are more likely to reduce HIV transmissions at the population-level. Further exploration to identify dyadic and structural barriers to treatment access and adherence among YBMSM are needed, since multi-level interventions targeting this group are lacking. A dyadic intervention delivered to HIV-positive YBMSM and members of their social support network improved retention in care and ART adherence.[117] To our knowledge, there are no structural interventions designed to improve HIV medication adherence among YBMSM.[116]

Facilitators and Barriers to HIV Medication Adherence in Qualitative Studies

Qualitative studies have identified numerous and intersecting domains that facilitate or hinder access and adherence to HIV treatment. For instance, unstable housing (structural-level barrier) could make it difficult for PLWHA to access HIV care services if they do not have a permanent address, which is required to complete eligibility paperwork for social health programs like Ryan White (RW) or Medicare (policy-level barrier).[200] Medication-related factors such as side effects or a high pill burden can make it difficult for participants to remain adherent to their treatment regimens, especially if it alters their lifestyle.[200,201] Other multi-level factors including social support (dyadic), transportation (structural), stigma and discrimination (structural), mental health (individual), and HIV status disclosure (dyadic), have been found to impact access and adherence to antiretroviral therapy (ART) among PLWHA.[200-202]

Utility of Further Qualitative Assessment

Although there may be some overlap, the multi-level factors affecting ART access/adherence within the general HIV-positive population may not be the same as those affecting treatment access/adherence among YBMSM. Because there is a lack of research on multi-level factors associated with ART access and adherence among YBMSM, qualitative

studies are ideally suited to identify potentially new domains of influence. Quantitative studies require the identification of exposures prior to study implementation. In contrast, qualitative studies do not require the identification of contributing factors *a priori*, enabling researchers to obtain a comprehensive collection of exposures that might otherwise be missed in quantitative studies. Qualitative methods can generate new hypotheses and characterize previously unknown causal pathways, which can later be tested and validated in quantitative analyses.

The causal pathways affecting HIV treatment access and adherence are often complex and involve a host of inter-related factors operating at multiple levels (intrapersonal, interpersonal, socioeconomic, political, and cultural).[202] For instance, social support (dyadic), coping skills (individual), stigma (structural), mental health issues (individual), and HIV status disclosure (dyadic) often work together to influence PLWHAs' ability to remain adherent to their therapy.[203,204] The negative effects of experiencing HIV-related stigma may be compounded by poor coping skills or a lack of social support, leading to the development of depressive symptoms, and a reluctance to disclose one's HIV status to others.[203,204] Insufficient income due to un/under-employment can result in unstable housing, making it difficult for PLWHA to take their medications without inadvertently disclosing their status to roommates.[200,201] Poverty can also result in food insecurities, which contribute to ART non-adherence if medications need to be taken with food to avoid severe side effects.[101,205,206]

Qualitative studies can delineate and clarify the temporal and hierarchical order of risk factors within complex pathways. In the paragraph above, we described how poor coping strategies can impact domains (social support, mental health, disclosure) related to ART adherence. If this pathway were validated in future studies, an intervention designed to teach

positive coping strategies to PLWHA may have a greater impact on improving treatment adherence compared to interventions targeting factors downstream the causal pathway.

Numerous qualitative studies have examined the challenges and successes HIV-infected youth face in adhering to their HIV treatment regimens.[207-210] However, few studies have focused on identifying these domains among HIV-positive YBMSM, who are at greatest risk for transmitting HIV to others. Two studies found that delayed developmental goals and exposure to racism, homophobia, and HIV-related stigma had a detrimental impact on ART adherence among HIV-positive YBMSM.[212,213] There is an increasing need for culturally and developmentally appropriate interventions that address access and adherence to ART within this population.[213]

Study Purpose and Aims

A comprehensive HIV prevention strategy should seek to reduce the HIV-uninfected population's vulnerability to HIV, combined with efforts to reduce the transmissibility of HIV within the HIV-infected population. In Aims 1 and 2, we investigated the relationship between HIV risk perception and behaviors that increase the risk of HIV infection among seronegative young Black and White MSM. In Aim 3, we transition to identifying domains related to factors (ART access and adherence) that directly affect HIV-positive YBMSM's transmission risk.

The purpose of this study is to identify multi-level themes related to access and adherence to HIV ART adherence among seropositive YBMSM receiving HIV care in Atlanta GA. A mixed-methods approach, including a semi-structured timeline interview was used to explore relevant experiences for four types of viral suppression categories: those who remained 1) virally suppressed, 2) virally unsuppressed, 3) gained viral suppression, and 4) lost viral suppression during the study period.

We also explored how clinical outcomes (viral suppression, HIV drug resistance), sexual behaviors, and qualitative themes related to treatment access and adherence were interconnected over the same time period. Clinical outcomes can be used to verify whether the domains identified in this study truly served as barriers or facilitators to ART access and adherence. Among participants with suppressed viral loads, we'd expect them report more domains that acted as facilitators to treatment access and adherence. It is also important to explore the sexual behaviors of YBMSM during times when their viral loads are stable or unstable. Because YBMSM are at greatest risk of transmitting HIV, it is important to investigate whether the occurrence of risky behaviors coincides with periods of viral instability. If true, these findings may help to explain the disproportionate number of HIV infections experienced by this population.

METHODS

Study Population Recruitment and Sampling

Twenty-five young, HIV-positive MSM who were receiving HIV care at the Ponce de Leon Center, part of the Grady Healthcare Network in Atlanta, GA were enrolled in the study. This urban, Ryan White (RW) HIV/AIDS Program funded clinic provides comprehensive medical care and social support services to over 5,800 individuals living with HIV/AIDS, and houses a separate pediatric/adolescent HIV department, making it an ideal venue to recruit for this study.[241] This clinic serves mostly African-American patients who are uninsured or underinsured, and economically disadvantaged.[241]

Venue-based, purposive sampling was used to identify and recruit eligible participants into the study. Purposive sampling is a criterion-based technique commonly used in qualitative research in which participants are chosen based on a specific set of characteristics or features that facilitate the detailed exploration and understanding of central themes of interest.[214,215] Because purposive sampling is non-random, our study sample may not be representative of the overall population of HIV-positive YBMSM engaged in care; though this type of sampling enables us to gain nuance and depth of understanding of a specific high-risk group of interest.[214]

Study Eligibility Criteria

Study eligibility consisted of the following criteria:

1) Male ages 18-39.
2) Reported having sex with another male in the past year or self-identified as gay/homosexual.
3) Treatment experienced, meaning they initiated ART at least six months prior to date of their first viral load measurement as part of this study.

4) Achieved a minimum level of retention in care (had at least two viral load measurements three months apart, over a 12-month period, starting from the date of their most recent viral load measurement as part of this study).[216]
5) Scheduled for an outpatient visit at the clinic.

Eligibility criteria were assessed with an initial screening call and confirmed through electronic medical record abstractions.

Viral Suppression Status

To ensure representation of a variety of viral suppression histories, we purposively sampled from four viral suppression typologies. Virologic suppression was defined as having an HIV RNA viral load less than 400 copies/mL. All viral load measurements were abstracted for a period that spanned the date of their most recent (before the study interview) viral load measurement to 12 months prior to that date. The four typologies were:

1. Suppressed – all viral loads suppressed.
2. Unsuppressed – all viral loads unsuppressed.
3. Gained suppression –viral loads went from unsuppressed to suppressed.
4. Lost suppression –viral loads went from suppressed to unsuppressed.

Because participants could have had more than two viral load measurements during this timeframe, a single participant may represent more than one suppression typology (e.g., participant gained suppression during one time period, and then lost suppression during another time period). We queried these periods separately during interviews. Viral suppression status was only defined using measurements that were at least three months apart from each other. We recruited enough patients to ensure at least five participants in each of the four suppression

categories were enrolled. Three participants who had both gained and lost viral suppression during the study period were counted in both groups when analyzing the data.

Electronic Medical Record Abstraction

The following data spanning the study period were abstracted from participants' electronic medical records: date of birth, VL measurements and dates, CD4 count measurements and dates, dates and frequency of HIV outpatient visits, date of HIV diagnosis, date of AIDS diagnosis, date of ART initiation (or earliest date of ART prescription indicated within medical records), HIV genotyping results, and dates of enrollment/re-enrollment into Ryan White (RW) care or the AIDS Drug Assistance Program (ADAP).

Quantitative Survey

Before the timeline interview, a short (~10 min.), self-completed electronic survey was administered in person to participants through SurveyGizmo (www.surveygizmo.com) via a tablet. The survey collected information on basic demographics (age, race, education, employment status, health insurance status, homelessness, incarceration), baseline risk behaviors in the past six months (number of sex partners, condom use and disclosure frequency, partner HIV status, illicit drug use), and HIV care characteristics (date of HIV and AIDS diagnosis, date of ART initiation). Survey questions were adapted from the first MSM cycle (2003-2005) of the NHBS.[217] The survey is attached in *Appendix D*.

Timeline Construction and Interview

A timeline was constructed that included the virologic status, and dates and measurements of all viral loads for the ~12-month period spanning the most recent and earliest measurements. We developed a semi-structured interview guide designed to elicit patients' perspectives about their experiences related to HIV treatment adherence. The interview began by

directing participants' attention towards the timeline, with the interviewer describing their VL measurements/status. For example, an interviewer might explain that the participant's VL was suppressed throughout this timeframe. The interviewer would ask open-ended questions regarding the participant's life during the time in question. The interviewer then probed to explore whether and how any particular events affected their access or adherence to ART.

The interviewer also administered a structured pile sort activity, which is commonly used to elicit responses regarding facilitators or barriers to ART access and adherence.[218] Participants were asked to sort the cards describing each of these factors into one of three piles relating to how they affected their treatment access and adherence during the study period: 1) factors that were not relevant, 2) factors that were beneficial, and 3) factors that were harmful. Participants were asked to discuss why they classified cards to facilitate nuanced discussion.

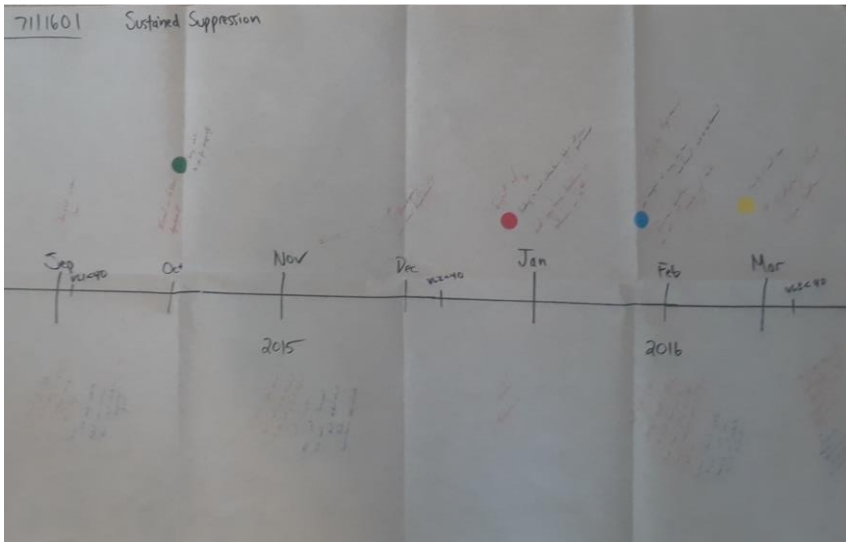
At the same time, participants were asked to annotate the timeline describing these events and how they may have influenced their ART access/adherence. Because retrospective interviews such as these are prone to problems with recall, annotating the timeline can serve as a temporal anchoring point that may aid participants in the recall of important events, and help to orient them to when they occurred.[219] Participants were given different color stickers to label whether the event was beneficial or harmful to their access/adherence, and were also asked to rank the events in order of influence.

In the last part of the interview, participants were asked to comment about the individuals they had sex with during this timeframe. They were asked how they met these partners, and whether these were long term relationships or casual encounters. Participants were also asked whether these partners offered any emotion or physical/tangible support, and whether this support helped or prevented them from accessing or adhering to their treatment regimens.

Interviewers instructed participants to write short descriptions of all their sex partners in terms of demographic characteristics (race, age, HIV status, partner type – primary/casual) and sexual behaviors (condom use frequency, sexual position) on the timeline.

Interviews were 1-1.5 hours and participants were compensated $40 in cash. Figure 4.1 provides an example of an annotated timeline used in this study.

Figure 4.1. Example of Annotated Timeline



Andersen's Behavioral Model of Health Service Use

Andersen's Behavioral Model (ABM) of Health Services Use is a theoretical framework for understanding how patient and environmental factors impact health behaviors and health service utilization/access.[200,220] The ABM model hypothesizes that health behaviors are a function of: 1) patient characteristics (predisposing, enabling, perceived need), 2) health care environmental factors (system, clinic, provider), and 3) external environmental factors.[200,220-222] Predisposing factors represent characteristics intrinsic to the patient (e.g., demographics, mental health, risk behaviors).[200,223] Enabling factors are resources and tools (extrinsic to the patient) that can enable or impede behaviors/health care utilization (e.g., housing, insurance, social

support).[200,223] Perceived needs are the patient's personal beliefs and values regarding their own health and health care, that may subjectively affect their use of health services.[200,223]

This model has been used extensively in the literature to organize and describe factors affecting health behaviors (e.g., adherence to ART,) and outcomes (virologic suppression, access to ART, retention in care, linkage to care) for PLWHA.[200,221,223-225] Andersen's Behavioral Model has been adapted to separate contextual factors (environmental, clinic-specific, provider-specific, system-specific) from individual-level characteristics, and health behaviors in explaining movement along the HIV treatment cascade.[200,222,224,225] This model also helps to organize and represent domains that impact health behaviors at multiple-levels. Individual-level factors affecting ART access and adherence include patient demographics and behaviors (e.g., age, race, education, substance use). Dyadic factors such as social support and one's relationship with their health care provider are represented in this model. Structural facilitators or barriers to ART access and adherence such as health care facility-related factors (e.g., appointment availability, clinic capacity), health care program-related factors (e.g., availability of mental health or substance use services), and external environmental factors (e.g., community-level stigma) are also included in this model. We used this adapted framework to guide the qualitative exploration of HIV treatment access and adherence among HIV-positive YBMSM.

Data Analysis

Codebook Development

All interviews were recorded using a digital audio recorder and transcribed professionally verbatim. Transcripts were uploaded into MAXQDA 12 (VERBI Software, Berlin, Germany) and analyzed. Transcribed interviews were coded for emergent themes (and subthemes) using an inductive approach. Preconceived theoretical ideas or hypotheses are not applied when coding

the transcripts.[226] Instead, a codebook (or code structure) is developed inductively, from the data itself or through the experiences of participants.[227] After each transcript was coded, the codebook was applied to the next transcript, further refining and developing existing codes to fit the data, while also introducing new emergent themes.[227] The code structure was finalized once no new concepts or themes were identified from reviewing the data.[200,226,227] On a single coder was used. Although the codes were developed using an inductive process, these codes were later deductively organized into an existing theoretical model (ABM).

Each code was labeled (subcode) as a barrier or a facilitator to ART access/adherence. For example, a participant may have mentioned that moving from one place to another (unstable housing) made it more difficult to adhere to their treatment regimens. The housing code would be given a barrier subcode to indicate that (unstable) housing contributed to poor adherence. Another participant may have described how the fear of developing further drug resistance to their treatment therapies motivated them to adhere to their current regimen. In this example, the drug resistance code would be given a facilitator subcode to indicate that the negative health consequences of drug resistance helped them to maintain proper adherence to ART.

Mapping and Frequency of Themes

The most common codes (themes) were organized using the ABM framework (Figure 4.3). The only ABM domain that did not come up in participant interviews was the contextual environment. We were able to organize all codes into the other six domains. The frequency of barriers/facilitators was summed for each theme in order to get a sense of the relative commonality of a particular experience (Figure 4.4). This sum represents the total number of participants who reported a specific theme as a barrier or facilitator (it does not represent the total number of times the participant reported that theme as a barrier/facilitator). For example, six

participants may have indicated that a lack of social support acted as a barrier to adherence, whereas three participants may have reported their social support networks helped them maintain a high level of adherence. A participant may have indicated that a single theme acted as both a barrier and facilitator during the timeline period, in which case that participant would be counted twice in the analysis (once as a barrier and once as a facilitator).

The frequency of themes that acted as barriers and facilitators was also observed by VL typology. For example, one participant whose viral loads were suppressed may have reported five themes that affected his ART adherence during the timeline period. Of these five themes, four acted as facilitators and one served as a barrier. For all participants who had suppressed viral loads, we summed the number of themes reported as barriers and facilitators. This will provide an indicator of whether the proportion of barriers/facilitators reported correlates with participants' VL status (e.g., 90% of themes reported by participants with suppressed viral loads acted as facilitators). The sum of barriers/facilitators was further viewed by theme and VL status so that we could identify for example, the most common theme acting as a barrier among participants with unsuppressed viral loads.

Frequency of Timeline Sexual Behaviors by Viral Load Status

Information annotated directly on the timeline (separate from the quantitative survey) included data on participants' sexual partners and sexual behaviors over the entire timeline period (which may be shorter or longer than the 6-month period used to collect data on sexual behaviors in the quantitative survey). These partner-specific behaviors were aggregated (any CAI, any serodiscordant CAI, disclosure to all partners) for each participant and observed by VL typology. Findings from this analysis may indicate whether participants are engaging in high risk

behaviors during the same time they are virally unstable, increasing their risk of transmitting HIV.

RESULTS

Baseline Demographics, Risk Behaviors, and HIV Care Characteristics of Study Sample

A total of 25 participants were enrolled in the study and completed both the quantitative survey and the qualitative timeline interview. Most participants were 30-39 years in age, Black, and self-identified as gay/homosexual (Table 4.1). Almost half were unemployed and a quarter were homeless. More than half relied on the Ryan White (RW) program to pay for their health care services and medications. In the 6 months prior to the study interview, the vast majority of participants were sexually active and engaged in potentially high risk sexual activities. Very few used condoms 100% of the time, and about a half, and a third of participants, respectively reported sex with serodiscordant and status unknown partners. About half reported using illicit drugs or engaging in sex while high or drunk.

On average, participants had lived with HIV for almost 9 years, and most had already been diagnosed with AIDS. Although all were treatment-experienced, with an average time of 7 years between first being prescribed ART to the study interview, participants on average waited almost two years post diagnosis to initiate ART. Almost three-quarters failed to renew their RW eligibility within one year of their most recent VL measurement, resulting in interruptions in the receipt and delivery of HIV care services. According to HIV genotyping test results, a majority of participants had previously developed secondary (non-transmissible) resistance to ART after diagnosis, indicating previous issues with adherence. Overall, we sampled similar numbers of participants whose VL were suppressed, unsuppressed, or unstable. On average, the timeline interview spanned (from the most recent VL measurement, to the earliest VL measurement within a one-year period from the most recent measure) a period of 9 months (Table 4.1).

Table 4.1. Baseline Demographics, Risk Behaviors, HIV Diagnosis and Care of YBMSM (N = 25)

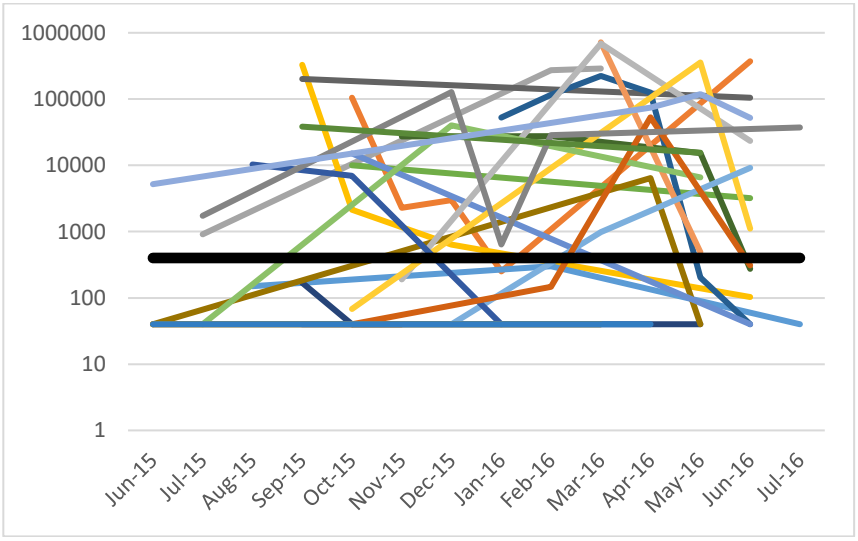
Demographics	**N (%)**	**Risk Behaviors (Past 6 Months)**	**N (%)**
Age		Any sex	23 (92.0)
18-29	6 (24.0)		
30-39	19 (76.0)	Average # of Sex Partners: Mean (Std. Dev.)	3.1 (2.7)
Mean (Std. Dev.)	31.5 (4.2)		
		Any sex w/ main partner	17 (73.9)
Race/Ethnicity			
Black/African-American	23 (92.0)	Any sex w/ casual partner	7 (30.4)
Latino/Hispanic	1 (4.0)		
Mixed Race/Ethnicity	1 (4.0)	Condom Use Frequency	
		Always (100%)	3 (13.0)
Sexual Identity		Most of the time (>50%)	10 (43.5)
Gay/Homosexual	21 (84.0)	Sometimes (<50%)	4 (17.4)
Bisexual	4 (16.0)	Never (0%)	3 (13.0)
Education		Disclosure Frequency	
High school, GED, or lower	10 (40.0)	Always (100%)	15 (65.2)
Some college or above	11 (44.0)	Most of the time (>50%)	4 (17.4)
		Sometimes (<50%)	1 (4.4)
Currently Unemployed	11 (44.0)	Never (0%)	3 (13.0)
Unemployed for > 1 yr.	6 (54.5)		
		Any sex w/ HIV-positive partner	19 (82.6)
Currently Homeless	6 (24.0)		
Homeless for ≤ 1 yr.	4 (66.7)	Any sex w/ HIV-negative partner	11 (47.8)
Health Care Payor Source		Any sex w/ HIV status unknown partner	8 (34.8)
Ryan White Care	16 (64.0)		
Medicaid	5 (20.0)	Used illicit drugs	12 (48.0)
Medicare	4 (16.0)		
		Any sex while high or drunk	11 (47.8)
Incarcerated in Past Year	2 (8.0)		

HIV Diagnosis & Care	**N (%)**		**N (%)**
Diagnosed w/ AIDS [3]	20 (80.0)	Time lived w/ HIV (since baseline) [1]	
		< 5 yrs.	4 (16.0)
Out of Care Recently [3,4]	18 (72.0)	5-10 yrs.	13 (52.0)
		> 10 yrs.	8 (32.0)
# Viral Load Measurements [3]		Mean (Std. Dev.)	8.7 (4.5)
2 measurements	5 (20.0)		
3-4 measurements	15 (60.0)	Time from diagnosis to ART Initiation [2]	
≥ 5 measurements	5 (20.0)	≤ 1 yr.	10 (40.0)
Mean (Std. Dev.)	3.5 (0.9)	> 1 yr.	15 (60.0)
		Mean (Std. Dev.)	1.9 (2.5)
Virologic Status [3,6]			
All VLs Suppressed	6 (24.0)	Time from ART Initiation to Study Interview [2]	
All VLs Unsuppressed	7 (28.0)	< 5 yrs.	10 (40.0)
Gained Suppression	8 (32.0)	5-9 yrs.	11 (44.0)
Lost Suppression	7 (28.0)	≥ 10 yrs.	4 (16.0)

		Mean (Std. Dev.)	6.8 (4.6)
Timeline Interview Length [7]			
≤ 6 months	4 (16.0)	Ever Developed Secondary Resistance [3,5]	19 (76.0)
7-12 months	19 (76.0)		
> 12 months	2 (8.0)		
Mean (Std. Dev.)	8.6 (2.5)		

Note 1: Percentages may not add up to 100% due to rounding or missing values.
Note 2: All outcomes are obtained via self-report measures unless otherwise stated.
[1] 44% (n = 1) had diagnosis years that differed between medical record abstraction and self-report (from quantitative survey). The earlier diagnosis year/month was used to calculate time lived with HIV.
[2] 68% (n = 17) had ART initiation years that different between medical record abstraction and self-report (from quantitative survey). The earlier initiation date was used to calculate time from diagnosis to ART initiation.
[3] Obtained from medical record abstrations.
[4] Defined as having to re-enroll in Ryan White Care or ADAP (AIDS Drug Assistance Program) at the clinic within 1 year of most recent viral load/CD4 count date.
[5] Only including secondary drug resistance (drug resistance developed after treatment initiation). Does not include primary drug resistance (drug resistance transmitted from infected to non-infected patients).
[6] Numbers add up to greater than 25 because participants may be included in more than 1 category (3 participants both gained and lost suppression during the study timeframe).
[7] Covers the time period from the first viral load measurement to the most recent measurement (before the baseline interview).

Figure 4.2. Viral Load Trajectories of 25 HIV-Positive YBMSM during Timeline Period



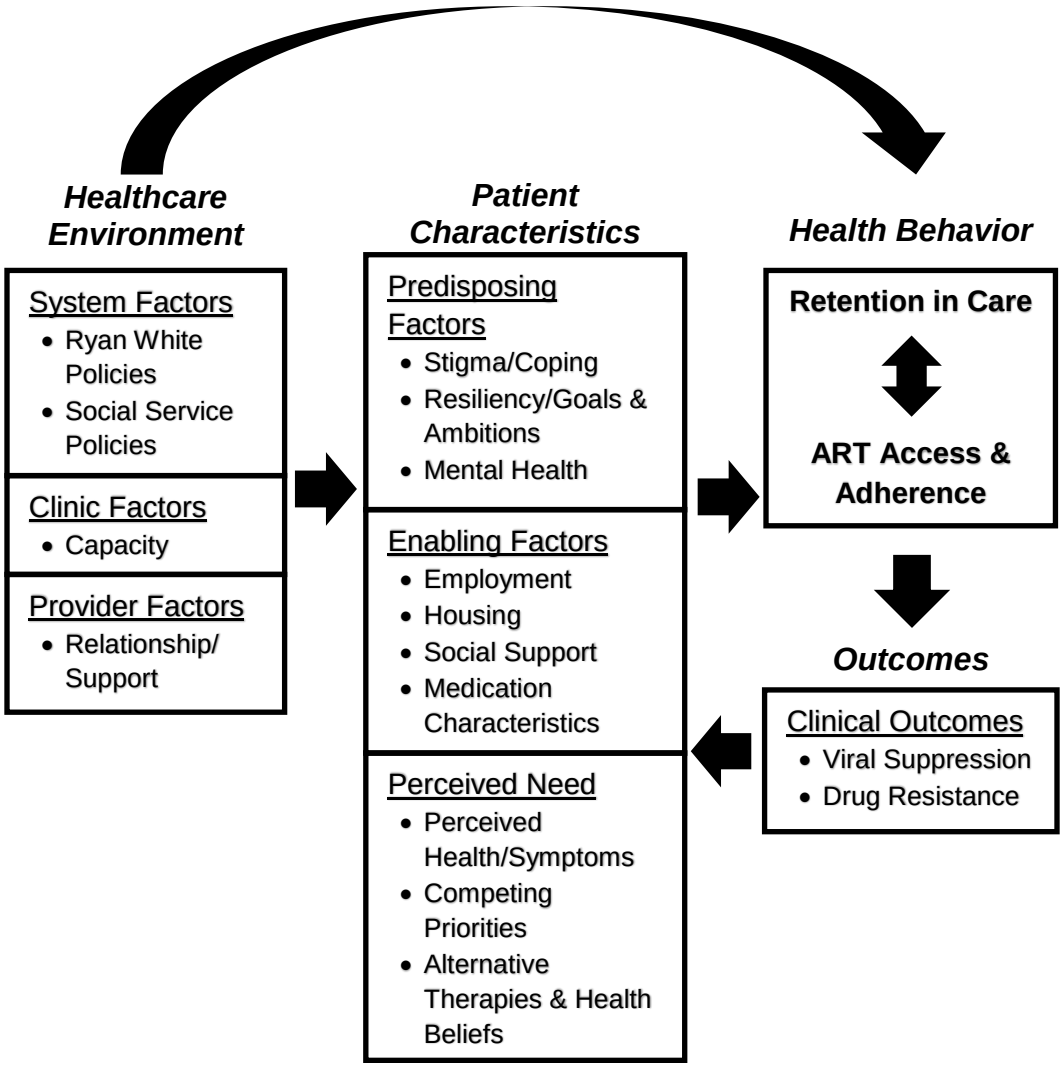
Note: Viral trajectories are a result of the purposive sampling (sampled participants that fit in four different viral categories).

Figure 4.2 depicts the VL trajectories of all 25 study participants during the study period. The black horizontal line represents the viral suppression boundary, which was set at 400 copies/ul. This figure indicates that our sample represents a wide range of stable and unstable viral suppression experiences.

Mapping out the Domains Related to ART Access and Adherence

Overall, participants identified a total of 15 separate codes representing barriers and facilitators to ART access and adherence, and more broadly, access and retention in HIV care. We used an adapted version of ABM to map out these 15 themes into eight domains (Figure 4.3).[224,225] Four codes were related to the healthcare environment and included system-level factors (Ryan White and social service policies), clinic characteristics (capacity), and provider-related factors (relationship/support). Ten codes related to patient characteristics included predisposing factors (stigma/coping, resiliency/goals and ambition, mental health), enabling factors (employment, housing, social support, medication characteristics), and perceived need (perceived health/symptoms, competing priorities, alternative therapies and health beliefs). Many of these codes were interrelated and worked in conjunction to impact patients' health behaviors and access to care.

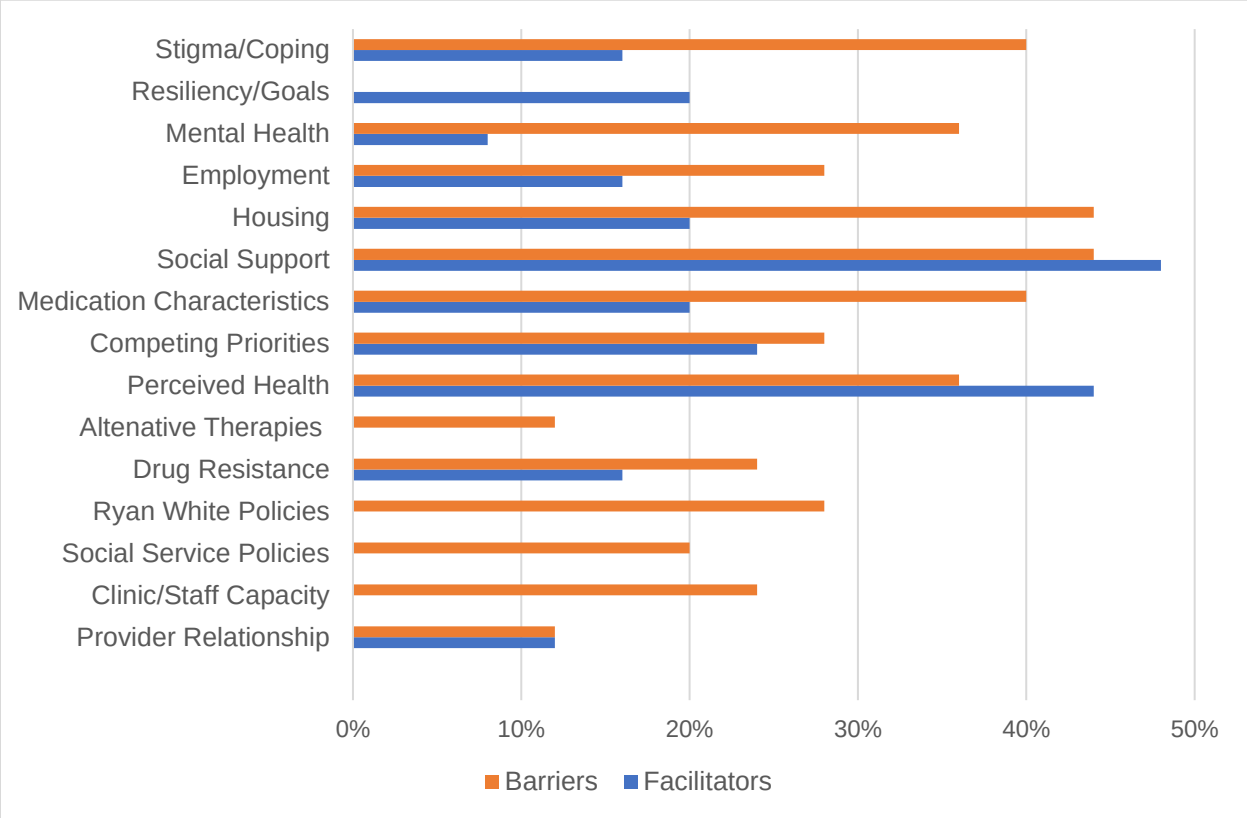
Figure 4.3. Multi-Level Themes Related to ART Access and Adherence Mapped to ABM



Frequency of Barriers/Facilitators to HIV Medication Adherence

Distribution of Barriers/Facilitators by Theme

Figure 4.4. Distribution of Barriers/Facilitators to ART Access and Adherence by Theme



This section describes the themes (codes) that were most frequently reported as barriers/facilitators to ART access and adherence. We also looked at the distribution of barriers/facilitators by viral load status, and by viral load status and theme.

Overall, the themes in which over 30% of participants reported as barriers to accessing or adhering to ART included: stigma/coping, mental health, housing, social support, medication characteristics, and perceived health/symptoms (Figure 4.4). The most common (with at least 20% of participants reporting) facilitators to HIV treatment access and adherence included:

resiliency/goals and ambitions, housing, social support, medication characteristics, competing priorities, and perceived health/symptoms.

Distribution of Barriers/Facilitators by Viral Load Status

We found that 71% of all themes reported by participants with suppressed viral loads (n = 6) were facilitators to treatment access and adherence. In contrast, 83% of all themes reported by participants with unsuppressed viral loads (n = 7) were barriers to ART access and adherence. Among those who gained suppression during the study (n = 5), 42% of all themes reported served as facilitators. Among those who lost suppression (n = 4), and those who both lost and gained suppression (n = 3), 70% of all themes reported served as barriers.

Distribution of Barriers/Facilitators by Theme and Viral Load Status

Among participants with suppressed viral loads (n = 6), the most commonly reported facilitators included: medication characteristics, stigma/coping, social support, perceived health, and competing priorities. The most commonly reported barriers for participants with unsuppressed viral loads (n = 7) included: social support, stigma/coping, housing stability, medication characteristics, and competing priorities. For participants who gained suppression (n = 8; includes three participants who both gained and lost suppression), the most commonly reported facilitators were perceived health, housing stability, social support, and resiliency/goals and ambitions. Among those who lost suppression (n = 7; includes three participants who both gained and lost suppression), the most commonly reported barriers were stigma/coping, medication characteristics, mental health, housing stability, employment, social support, perceived health, and competing priorities.

Timeline Sexual Risk Behaviors by Viral Load Status

Most participants (in all viral status categories) reported sex during the timeline period. On average, those who gained suppression (n = 8) reported the fewest number of sex partners. All participants whose VL were either entirely suppressed (n = 6) or unsuppressed (n = 7) reported engaging in CAI. Participants with suppressed VL and those with unsuppressed VL, respectively had the lowest and highest rates of disclosure to all sex partners. Similarly, suppressed participants had the highest rates of serodiscordant (partner's HIV status was negative) CAI, followed by those who gained suppression, those who lost suppression (n = 7), and those with unsuppressed VL.

Description of Multi-Level Themes Related to ART Access and Adherence

Patient Characteristics – Predisposing Factors:

HIV-Related Stigma/Coping

In this study, participants experienced stigma at the individual-level (internalized stigma), dyadic-level (discrimination), and at the structural-level (stigma within their community). People living with HIV/AIDS (PLWHA) have little control over their exposure to stigma from the external environment, and their propensity to internalize its negative effects can impact their health behaviors. Participants experienced stigma in the form of discriminatory acts, which they described as resulting in feelings of shame and embarrassment (Table 4.2). Many participants also detailed avoidance or passive coping strategies, including denial (of one's HIV status), disengagement (from people), and inaction (not dealing with stressors), which they believed contributed to poor self-management of their own health. Because their treatment regimens reminded them of their HIV diagnosis, a number of participants stopped taking medications regularly to avoid feelings of shame (Table 4.2). Some participants described difficulty with

disclosing their HIV status to their roommates, family members, or friends for fear of being judged, discriminated against, or rejected (Table 4.2). These individuals reported poor ART adherence, skipped medical appointments, and did not refill their prescriptions in an effort to conceal their status from others.

Participants who were successful in accessing care and adhering to their treatment regimens described utilizing functional coping strategies including reappraisal or positive reframing, defined as the reinterpretation of a stressor in a positive light.[228-230] These individuals viewed ART in the same manner as any other medications used for health conditions such as diabetes or cancer (Table 4.2). Participants explained that their positive mindset helped them remain adherent, despite regularly dealing with homelessness, drug addiction, stigma, and discrimination.

Resiliency/Goals & Ambitions

A few participants indicated that having specific goals or ambitions provided them with the necessary motivation and inspiration to successfully maintain or improve their adherence levels, despite facing challenging circumstances (e.g., deaths of close family members or friends, dissolution of relationships). This motivation primarily came from those who provided both material and emotional support (dyadic factor). These participants reported a strong desire to live in order to spare loved ones from the mental anguish and trauma that would result from their death, and ensure their previous efforts in helping them maintain their health were not made in vain (Table 4.2). Resiliency also came from structural influences within participants' neighborhoods. One participant was motivated to adhere to his treatment regimens to invalidate HIV-related stigma ubiquitous in the Black community (Table 4.2). Other participants wanted to

maintain their health so that they could raise a family, or had ambitions to pursue and excel in a career they were passionate about (Table 4.2).

Mental Health

Numerous participants experienced chronic and/or temporary manifestations of mental illness (individual-level theme) both during the study period and since the time they were first diagnosed with HIV/AIDS. Some of the more severe manifestations of mental illness reported by participants included psychotic or bipolar disorders, and suicidal ideations (Table 4.2). A few participants described how engaging in negative coping strategies (e.g., denial, disengagement, inaction) made it more difficult to access and adhere to HIV therapies, and frequently coincided with prolonged bouts of depression. Even after living with HIV for many years, one participant continued to express regret over his diagnosis, imagining a "normal" life had he not been infected (Table 4.2).

Some participants explained how temporary, but potentially recurrent bouts of depression were triggered by events at multiple levels, such as the death of a close family member or friend (dyadic), dissolution of a relationship (dyadic), lack of employment (structural), and the emergence of health complications (individual). A few participants believed their death was imminent, which summoned feelings of hopelessness and contributed to poor adherence to ART (Table 4.2**)**. Participants also described how their depressive symptoms made them lazy and lack the motivation to attend medical appointments, refill and/or pick up prescriptions, or adhere to their treatment regimens (Table 4.2). In contrast, those who were not struggling with mental health problems or those who were effectively treating (via medication) severe forms of mental illness reported more success in maintaining optimal adherence levels.

Patient Characteristics – Enabling Factors:

Employment

Multiple participants reported that structural aspects of their employment including long or irregular hours, and specific job responsibilities created barriers to their access and adherence to ART. A few participants who worked long hours either forgot to take their medications, or did not have time to take them while working (Table 4.3). One participant explained how long work hours made it more difficult to access HIV care services (e.g., seeing his physician/picking up prescriptions) during normal business hours, and another described how drastic changes to his work schedule forced him to change his daily routine, including the timing of his medication doses (Table 4.3). A few participants described how their job responsibilities often clashed with adhering to their treatment regimens, by exacerbating HIV medication-related side effects. For instance, one participant who did not have time to eat while he was working, or another whose job required him to drink alcohol (e.g., waiters needed to drink in order to describe and sell product to customers), reported being wary of taking their medications as prescribed, because they would be subject to severe side effects, negatively affecting their job performance (Table 4.3).

Employment benefitted other participants, providing them with the financial means to meet basic needs (e.g., secure stable housing, transportation, clothes) (Table 4.3). Numerous participants reported that only after these needs were met, were they able to focus on their health and well-being. A set working schedule also provided more structure, enabling a few participants to establish and maintain a daily routine. It was common for these participants to keep a consistent medication schedule in large part determined by their work hours, since medication-related side effects were likely to disrupt their job responsibilities. A few participants who found

happiness and satisfaction from their jobs were further motivated to remain healthy and adhere to their treatment regimens (Table 4.3). They described how their jobs gave them a sense of purpose, and belief they were on a path to fulfilling their goals and ambitions.

Housing

Approximately one-quarter of participants reported they were currently homeless at the time of the interview, and many described experiencing some form of unstable housing (structural factor) during the timeline period (Table 4.1, 4.3). Some participants described how moving from one place to another disrupted their medication schedules, and the constant threat of homelessness generated additional stress and anxiety (Table 4.3). A few participants forgot to take their medications with them when moving to a new place, and often, did not have a secure and safe location to store them (Table 4.3). For one participant, having to constantly move made it more difficult to keep track of and attend his medical appointments, resulting in a loss of health care coverage (Table 4.3). Multiple participants indicated that securing stable housing took priority over addressing their health care needs.

Housing stability is frequently defined as a function of type (owning vs. renting, living in a shelter or a hotel/motel, etc.) and duration (how frequently one moves from or stays at a residence).[231,232] Although these aspects of housing stability can affect ART access and adherence in numerous ways (e.g., no safe place to store medications, no permanent address for which to apply for aid), it was more common for participants to report that the people they lived with were responsible for creating an environment that compromised their adherence. In particular, multiple participants described how their inability to disclose their HIV status to their roommates (dyadic factor) made it more difficult to adhere to their treatment regimens. Especially in situations where privacy was limited (e.g., when roommates are sharing the same

room), these participants explained how they opted to skip doses of their medications when roommates were present, so as not to reveal their HIV-positive status (Table 4.3).

Social Support

Participants primarily benefitted from social support (dyadic theme) through one of two forms: 1) emotional, and 2) material. Relationships with other HIV-positive individuals (via HIV-positive support groups or partnerships) provided an outlet for participants to share their struggles with those who had experienced similar hardships. Persons living with HIV/AIDS who were happy, healthy, and led successful lives served as role models for participants, further motivating them to remain adherent to their treatment regimens (Table 4.3). One participant described how interactions with these support networks helped to normalize HIV as if it were any other disease, and provided him with a forum from which to glean a wealth of knowledge regarding ways to effectively manage his illness (e.g., information on HIV medications and related side effects), and navigate social relationships while seropositive (Table 4.3). A few participants involved in seroconcordant relationships benefitted from constant reminders from their partners to take their medication, which also doubled as a collaborative activity (Table 4.3). Another participant depended on family members and loved ones for transportation to and from medical appointments, financial support, and help recovering from medical procedures (Table 4.3).

Participants who had trouble disclosing their HIV status to family members, friends, and partners were more likely to lack a strong social support network. Even if they wanted help from others, there was no opportunity to receive it without revealing their HIV status. These participants often struggled with their adherence and desired to have someone they could confide in and talk to about their condition (Table 4.3).

Medication Characteristics

Three medication-related factors frequently affected participants' adherence to ART: 1) medication-related side effects (individual, structural), 2) medication scheduling (individual, dyadic, and structural), and 3) HIV treatment fatigue (individual). Many participants experienced a wide range of severe side effects including fatigue, drowsiness, night sweats, nightmares, diarrhea, and vomiting. Numerous participants described how side effects prevented them from getting adequate sleep, making them late for work and negatively affecting their job performance, ultimately making it difficult for them to keep a steady job (Table 4.3). Some participants had to choose between adhering to their treatment regimen or maintaining a normal lifestyle. Medication-related adverse events were debilitating to the point where it became impossible to complete normal, day-to-day tasks, including attending their medical appointments (Table 4.3). These participants often skipped doses so that they could function at their job or fulfill any plans they had for that day.

Because HIV treatment regimens require daily intake, consist of potentially complex dosing schemes (high pill burden and dosing frequency), and often come with numerous side effects and restrictions (e.g., medicine must be taken with or without food, with plenty of fluids, etc.), PLWHA have a difficult time successfully integrating their regimens into their daily routines.[207-209,233-235] As discussed in previous sections, inconsistent medication schedules resulting in poor adherence can often be brought about by long or erratic work schedules (structural), debilitating side effects (individual, structural), unstable housing (structural), a lack of functional coping skills (individual), or difficulty with disclosure (dyadic). Multiple participants who remained undetectable throughout the study followed a strict dosing schedule. Even when disruptions occurred in their daily schedule (e.g., traveling on vacation, special

events including birthdays, changing work schedules), these participants temporarily adapted their dosing schemes to fit their needs (Table 4.3).

HIV treatment fatigue, defined as a "decreased desire and motivation to maintain vigilance in adhering to a treatment regimen among patients prescribed long-term protocols", has been well-established as a barrier to adherence in previous literature.[200,208,210,234-237] A few participants expressed how they felt exasperated and incredulous at the thought of having to take medication for the rest of their lives, describing their situation as being "married to meds" (Table 4.3). These participants often stopped taking their medications for a period of time (i.e., "treatment holidays").

Patient Characteristics – Perceived Need:

Competing Priorities

Participants who prioritized their health were more successful at maintaining high levels of adherence and stabilizing their VL levels compared to those with competing priorities (Table 4.4). For many, adhering to treatment regimens and accessing HIV care services took a back seat to fulfilling basic needs, which included securing stable housing, addressing food insecurities, obtaining a steady job, paying bills, or maintaining relationships (Table 4.4). These participants believed that only after these structural needs were met, would they be able to focus on their health.

Perceived Health/Symptoms

Participants' perceptions and beliefs about their own health (individual-level theme) had a substantial impact on their health behaviors. Because HIV is a chronic disease characterized by a long, asymptomatic period, it is easy for PLWHA to believe they are "healthy" and ignore the long-term consequences (e.g., drug resistance, opportunistic infections, accelerated progression

of disease) of poor adherence. Numerous participants described how they delayed seeking care, stopped taking their medications altogether, or skipped doses of their treatment regimens because they felt healthy (Table 4.4). Some of these participants experienced severe negative health outcomes (e.g., significant weight loss, hospitalizations, thrush, stomach virus), which forced them to address their health and restart their treatment regimens (Table 4.4). These participants described how the fear of death and the rapid deterioration of their health motivated them to maintain high levels of adherence (Table 4.4). Other participants were stuck in a continuous cycle, where they planned to revert back to medication non-compliance once they felt healthy again.

Alternative Therapies & Health Beliefs

Complementary and alternative medicine (CAM) are holistic or "natural" approaches to HIV care that encompass a variety of therapies, including: mind-body based techniques (yoga, exercise, massage, medication, chiropractic practices), whole medical systems (homeopathy), biologically based or natural products (vitamins, supplements, herbs, marijuana), energy therapies (acupuncture, magnets), and spiritual healing.[238] Multiple participants reported using a wide array of alternative therapies (individual-level theme) including changes to their diet and exercise habits, and the use of supplements (e.g., Colloidal silver, elderberry gummies, Cat's claw, selenium, alkaline water, herbs) (Table 4.4). Participants who used CAM struggled with their adherence as evidenced by their detectable/unstable VL levels. They believed these "natural" therapies would improve their health, strengthen their immune system, and suppress the HIV virus (Table 4.4). Some participants had stopped taking their medications altogether, believing that alternative therapies alone would allow them to effectively treat, and even cure them of their infection (Table 4.4).

Clinical Outcomes:

HIV Drug Resistance

Through patients' medical records, we discovered that 76% of participants had developed any form of secondary drug resistance (individual-level theme) after initiating ART (Table 4.1). The development of drug resistance (resulting in virologic failure) motivated numerous participants to make their health and treatment adherence more of a priority in their lives (Table 4.4). This was similar to the prior observation in which improvements in health-seeking behaviors were made after participants experienced adverse health outcomes. Many participants reported being well aware of the difficulties involved in treating a multi-drug resistant HIV strain, fearing that further development of resistance would lead to limited treatment options and accelerated progression of disease (Table 4.4).

Drug resistance also acted as a barrier to adherence by making treatment regimens more complicated (structural factor). Participants reported taking up to seven different pills daily, as part of their HIV treatment regimens (Table 4.4). These participants who previously had trouble adhering to simpler regimens, were stuck in a perpetual negative feedback loop, where subsequent development of drug resistance resulting in larger pill burdens, increased the likelihood of future treatment non-compliance.

Healthcare Environment – System Factors:

Ryan White Renewal Policies

As part of the study eligibility criteria, all participants were retained in care according to Health Resources Service Administration (HRSA) guidelines.[216] However, almost three-quarters of participants let their RW eligibility lapse in the one-year period prior to their study interview, creating gaps in coverage during which they did not have access to HIV care services and ART

(Table 4.1). Many of the participants who did not recertify in time experienced unstable VL levels. They described the process of regaining eligibility (e.g., obtaining the required documentation and scheduling appointments to meet with the benefits specialist, case manager, or healthcare provider) as confusing, burdensome, and time-consuming (Table 4.5). Those who had jobs or did not have their own means of transportation found it difficult to go to the various agencies to acquire the necessary eligibility documentation.

A major factor facilitating participants' loss of health care coverage was the structural policy requiring them to renew their RW/ADAP eligibility every six months (Table 4.5). The combination of a frequent renewal requirement, along with patients' tendency to miss their scheduled appointments, created many opportunities for participants to fall out of care (Table 4.5). We will discuss how skipped appointments contributed to lapses in coverage in a later section (Clinic/Staff Capacity).

Social Service/Health Insurance Policies & Navigation

Most participants reported utilizing numerous federal assistance programs, including Supplemental Security Income (SSI), Social Security Disability Insurance (SSDI), Medicaid, Ryan White (RW)/ADAP, and Affordable Care Act (ACA) subsidies to supplement their income and receive affordable health care services. During the timeline period, multiple participants reported transitioning from one health insurer to another, mainly for failing to meet income eligibility requirements (structural factor). This process is often known as "churning", which describes the involuntary movement from one health plan or system of coverage to another, leading to a loss of retention and disruptions in access to vital care services and medications.[239-241] One participant described how he was dropped from Medicaid because his income exceeded eligibility limits, forcing him to choose to either pay for costly services and medications out of

pocket, resulting in massive debt, or forgoing urgent care until he could obtain health care coverage (Table 4.5). The same participant described how he was compelled to take part-time or lower paying jobs so that he could continue to receive affordable health care, fostering dependence on government programs, while also inhibiting the financial independence needed to secure stable housing and other basic needs (Table 4.5). Differing structural policies and eligibility requirements across programs and geographic boundaries also discouraged this participant from moving to another state for a job, for fear that his health care coverage would be disrupted (Table 4.5).

One participant had trouble obtaining food stamps when switching his welfare payer source from SSI to SSDI. This patient was denied eligibility because the government database incorrectly indicated he was receiving payments from both sources. This subsequently contributed to food insecurities and suboptimal adherence, since he explained how his medications needed to be taken with food to prevent severe side effects. Another participant obtained health insurance in the private marketplace using ACA subsidies. Unable to pay the monthly premiums/deductibles, this participant had to wait three months, during which he did not have access to HIV care services and ART, before he could cancel the plan and reapply for coverage through RW (Table 4.5). A participant also described how he was required to switch treatment regimens when transitioning from one health care program to another (e.g., from Medicaid to RW/ADAP) since they carried different HIV medication formularies (Table 4.5).

Healthcare Environment – Clinic Factors:

Clinic/Staff Capacity

Numerous participants complained about having to reschedule missed medical appointments weeks, even months after the original appointment date. According to participants,

the delays in rescheduling were a result of an overburdened clinic and staff (structural factor), who provide care for thousands of patients (Table 4.5). In many cases, rescheduling visits resulted in gaps in care during which participants' RW eligibility lapsed (Table 4.5). A delay in seeing their health care provider also made it more likely that participants would exhaust their supply of medications before they could obtain a prescription for a refill. Multiple participants had appointments scheduled after the date their supply of medication ran out (Table 4.5). These participants explained that they refill their ART prescriptions on a month to month basis for a set amount of time (e.g., 6 months) before they are required to see their physician again to obtain another prescription.

A few participants had problems picking up their prescriptions from the on-site pharmacy in a timely manner. Due to excessive patient volume, these participants reported waiting several days after seeing their physician before they could pick up their medications, when normally, they'd be able to pick up their medications on the same day the prescription was written. One participant called in to refill his prescription a few days in advance only to find out his medications weren't ready, contributing to missed doses (Table 4.5). The pharmacy only allowed patients a small window period, usually only a few days before they ran out of medication, to call in to have their prescriptions refilled.

Healthcare Environment – Provider Factors:

Provider Support

Although family members, friends, and partners served as important sources of support, participants' relationship with their health care provider (dyadic theme) also played an important role in their health and well-being. One participant described cycling from one doctor to another in search of someone who not only treated his physical ailments, but cared about other aspects of

his life (Table 4.5). On top of HIV-related illnesses, PLWHA often have to deal with other comorbidities, are commonly afflicted with mental health or substance use disorders, and often have problems securing stable housing.[201,242-246] Many participants advocated for a holistic approach (of treating the person and not the condition) to their health care, and described how they wanted their health care providers to understand and address the fundamental and underlying causes contributing to their physical, emotional, and material hardships (Table 4.5).

Participants who were successful in suppressing their VL levels had access to a health care team that was not only charged with improving their physical health, but who also provided emotional support, empathy, and encouragement. One participant described how his physician gave him his personal cell phone number, often checking up on him, and provided an outlet for the participant to express his struggles and difficulties with living with HIV/AIDS (Table 4.5). Other providers addressed mental health issues, encouraged patients to eat properly and exercise, and motivated them to adhere to their treatment regimens and achieve better lab results. Those participants who were struggling with their adherence reported negative experiences with previous health care providers, and desired to have a supportive relationship with a provider who they could connect with emotionally (Table 4.5).

Table 4.2. Participant Quotes for Predisposing Factors Impacting ART Access and Adherence

Stigma/Coping	"There was my mother who was very ignorant about HIV/AIDS. When I got out of prison, I would get paper plates and you know everybody else is eating on porcelain." (38 yrs., suppressed) "I've been dealing with HIV for 12 years and I was having difficulty taking the medicine, keeping it private. Certain family members know, certain friends know. It was a privacy thing because I don't want to be judged because I see how people talk about it, and I see how friends talk about other friends. So I know I can't tell them because I know they'll do me the same way." (37 yrs., lost suppression) "When you start meeting people or start talking to people, you are going to have that conversation about whether you have HIV or not. And...I'm sick of being rejected of that defect. So that was kind of my basis on why I stopped [taking my medication]...I'm sick of just being positive." (31 yrs., unsuppressed) "It doesn't bother me. Like what's the difference between this and a person with cancer? Diabetes can take your body out of here. Like, anything can take you up out of here." (35 yrs., suppressed)
Resiliency/ Goals & Ambitions	"I still have a really strong will to live…And to be honest with you, it may even have come from a little bit of like shame… I wouldn't want the story to be, we died of HIV or AIDS related illnesses. And it was that pride, that I was just like, I would rather get hit by a bus. And it sounds stupid, but it's true like how other people view us and there's so much stigma attached to it, like that's the last thing I wanted." (29 yrs., suppressed) "He won't want me to basically give up now especially as much as the hard work that he put into for me to you know continue to stay alive. He spent six months in and out of the hospital. I mean, no matter where he was working or where he was living, he'd always come and see me...And though he's not here, my brother is the reason why I'm taking my medicine. Because if I don't, then that means he spent a whole lifetime you know, supporting me for nothing." (30 yrs., suppressed) "I want kids one day, and then too, I want to live. I want a life too and third, I got family too. So those three things were maybe enough for me to take my meds." (21 yrs., gained suppression)
Mental Health	"And on top of that, you know, I'm bipolar. I got a lot of things going on with me." (Participant 15, 38 yrs., lost suppression) "I went into a depression – all of this because of my status. I just started feeling, only if I wasn't dealing with this, my life would be normal. I would be working, still being able to take care of myself. I don't have to take care of all these meds." (37 yrs., lost suppression) "Sometimes it made you not want to [take medication] and sometimes I just say you know, why am I taking this - eventually I'm going to end up dying." (34 yrs., gained suppression)

	“So I'm sure I still have some type of depression and like laziness. Whatever it is that's associated with not taking care of yourself. So it's not just like I'm not taking the medicine, it's more of I'm not taking medicine and I'm not like you know exercising, I'm not eating properly. When I do that, it's not like only taking my medicine that's incredibly hard -- like my whole lifestyle is just not healthy.” (31 yrs., unsuppressed) “I take the medicine and I am happy. I do everything if I am happy and I am happy right now with myself, and doing what’s right for me.” (33 yrs., unsuppressed)

Table 4.3. Participant Quotes for Enabling Factors Impacting ART Access and Adherence

Employment	"Every once in a blue moon, like if I work say 16 hours a day, I forget to take my medicine." (28 yrs., gained suppression) "But then there was me trying to get back and forth to the doctor which shouldn't be an issue, but it was an issue because trying to work seven days a week and I'm there from 8 to 8 at night. It's like when do I have time to go to the doctor." (25 yrs., unsuppressed) "I was really into my work. So that was very fulfilling to me. It made me feel good, like I was going to get to a place where I am going to soar in the business basically. I wanted to be healthy because this is just something I like to do." (30 yrs., suppressed) "You had to attend wine courses. You had to drink no matter what, even though you're like, "I can't today. Well, just taste it because you need to learn to sell it." So then that doesn't work with your medication." (Participant 9, 33 yrs., unsuppressed) "Now that I have a job, I am able to do what is needed for me to survive, to have my own place, be able to get around, be able to buy the proper clothes, and keep myself looking nice." (25 yrs., unsuppressed)
Housing	"I was actually living with a family member and they decided to move which left me out in the streets. So I was like bouncing from house to house." (25 yrs., unsuppressed) "But not really having the physical, a secure place to stay, you know still stresses me out." (32 yrs., gained-lost suppression) "Because I know that I have had issues with like bringing my medicine with me and like moving. So I know in the past, there's definitely been a correlation between you know me not having shelter on my head and me taking my medicine." (31 yrs., unsuppressed) "…and I think I missed my appointment at one time and didn't get to go get a refill after that because I missed my appointment. I guess that coincides with moving around and so forth. It's kind of hard to keep everything moving together." (32 yrs., unsuppressed) "And it's only a two-bedroom - very small. So with her and the kids, me and my spouse, that was very crowded…and I didn't want them to see me taking my meds there so I can honestly say I took my meds maybe two or three times when I was there." (28 yrs., lost suppression)
Social Support	"And then to be around people who were all HIV positive and young and virally suppressed, also motivates me to make sure I take care of myself." (29 yrs., suppressed)

	"… but it also gave me like a nice little network of people that I can talk to and say, "Hey, how long did it take you to feel better?" or "What are some of the issues that you deal with when it comes to dating?"." (29 yrs., suppressed) "…my partner also has HIV. So, it's kind of – you feel more comfortable about me taking my medicine. So he keeps me up on things too as well and I don't have to beat around the bush or hide anything." (38 yrs., gained suppression) "When I lost my job and I was like getting really ill, obviously you need financial support…But I mean as far as like food, transportation – I depend a lot on my sister for almost everything and of course my mom. But even to this day, like my sister is a pretty big help financially..." (Participant 21, 29 yrs., sustained suppressed) "I just guess that I feel like I needed somebody to support me, not necessarily remind me because I would always remember, but just to be a support system with taking my medicine. So, it really definitely affected me because I felt like I didn't have anybody that I could talk with or go to confide in about the condition." (32 yrs., gained-lost suppression)
Medication Characteristics	"This one, Atripla… it was like a psychotropic type drug. And weird dreams, night sweats. You don't get a good night's sleep when you take that medication. So, I would wake up feeling it all throughout the night and not being able to jump off and go to work at nine in the morning." (33 yrs., unsuppressed) "Because if I knew I had to do some things like when I have a doctor's appointment I don't take my meds in the morning because I know how sleepy they make me. I take them after my appointment. If I have something to do, the meds would be put on the back burner, probably at times I would miss a regimen or maybe miss the second part or maybe miss the first part. Because I know most of the time if I took them, I wasn't going to do anything." (37 yrs., lost suppression) "And I know when I'm entertaining myself or I'm entertained by family, we like to drink. But that time, I said, well, I'll take my medicine in the morning because if I take them at night while I'm drinking, the side effect is more so going to put me to sleep and I'd rather be up and party with my family all night and celebrate you know, my life and my twin brother's life." (30 yrs., suppressed) "Some days I wake up and I say, "I don't want to take medicine no more", or when it's time to take my meds, I think about it and say, "Not today." I just don't want to do it you know. It's the thought of knowing I got to take this for the rest of my life, is mind blowing." (34 yrs., gained suppression)

Table 4.4. Participant Quotes for Perceived Need and Clinical Outcomes Impacting ART Access and Adherence

Participant Quotes		
Perceived Need	Competing Priorities	"It's like, yes, I want to be successful, and I want to have a company and a business, but my health takes precedence over that. So if I have to choose between the two, I'm going to choose my health", 29 yrs., suppressed) "Everybody has a hierarchy of needs, you know you want a roof over your head, you want food in your stomach, and you worry about things after that later. If I'm homeless, the last thing I would be worrying about right now would be, "Where am I going to find my medication?" I would be like, "Screw that. I need a roof over my head first and then I will come back to that."" (29 yrs., suppressed) "So I mean if I continue on a path where I'm struggling with homelessness or struggling with money, or you know, having toxic people or toxic relationships, I'm definitely going to have issues staying adherent with my medicine because that's going to be the least of my worries. You're not going to think so much about taking your medicine because you don't have a roof over your head or you don't have money to put food in your mouth or whatever." (31 yrs., unsuppressed)
	Perceived Health/ Symptoms	"Years ago, when I was first starting the medicine, and I have gotten undetectable, like really fast…so like an idiot, I just took that and I kind of like fell into the state of, "I'm undetectable. I'm good, like I beat this. I'm not taking my medicine anymore, I don't need to. I feel healthy." So I stopped taking my medicine for like literally over a year." (28 yrs., gained suppression) "I just know it is important to take my medicine and there'll be times where I don't feel sick or look sick or whatever. And, like I have used that as an excuse to not take it." (31 yrs., unsuppressed) "I had a real, real bad stomach virus. I don't know what is was, but I couldn't eat well. I was sick for about two or three weeks…I had lost like – I think I lost like 25 pounds in like two weeks, you know…I got sick and I had to come to the doctor. I had no choice. And that's what put me back on my medication." (32 yrs., lost suppression) "But at that time when I was getting ready to graduate, I started feeling really, really sick. I had lost a lot of weight. It was just like all of a sudden. I'm 135 pounds and overnight, I was like 90 pounds. It was like that quick. And then I guess right after that, my skin started feeling real itchy, scratchy, like you know, thrush. Just throwing up, just feeling weak, just unable to take care of myself. Just looked very fragile, you know, just health scares. I just started to have all kinds of health issues. I didn't want to die, so that's when I started getting my meds." (31 yrs., unsuppressed)

	Alternative Therapies & Health Beliefs	"Because I was trying to like be more like natural so I would like go get elderberry gummies and like all types of you know, other things I would read. We were buying like Cat's claw and like elderberry and like all types of herbs and things that really were like good for your immune system." (31 yrs., unsuppressed) "But like I said when I first came in, I had full blown AIDS. So I noticed when I was taking this [supplement] and he said, "Your numbers are doing really good." I was like "Okay, so that means that it is helping and it is improving". So I said, "Okay, so let me take this approach." So what I pretty much found out is there are some things that deal with viral or fungal diseases." (31 yrs., lost-gained suppression) "I have a friend who is HIV positive and he's not taken medication. He's always done things naturally. So that lets me know that something can be done. So I looked at that as a sort of inspiration. And I said, "Well let me try it."...and I stopped buying my [HIV] medication about that time. And the reason I had stopped – I want to try and do more of a natural thing. Because one of my personal beliefs is that through certain [CAM] regimens, certain things can be fixed." (31 yrs., unsuppressed)
Clinical Outcomes	Drug Resistance	"Because I became resistant after not taking meds and then I got scared. So now I am taking the medicines because if I stop taking them, I might become resistant to other medicines." (32 yrs., suppressed) "…that's when I got this news and I was told to stop taking the Stribild because I built a resistance. So that was the hard lesson that I took because I thought…I can take a few days off here, take a few days off there, but then it caught up with me…So now I got to take three pills, so that's my wakeup call. I can't mess this up because if I rule out Truvada, then that rules out an entire class of medicine for me. And that makes it difficult to treat, which means more pills I have to take if I mess this up." (38 yrs., lost suppression) "I take so many meds, I probably take like…6 or 7 antiretrovirals along with other stuff I have to deal with. I have put myself in a place where I said I have to take them. I just came to realize this is part of my life…I can't start and then stop and then start because it's going to come to a place where I can't get any meds because my body will be resistant to everything." (37 yrs., lost suppression)

Table 4.5. Participant Quotes for Healthcare Environmental Factors Impacting ART Access and Adherence

Participant Quotes		
System Factors	Ryan White Policies	"This paperwork is not easy and straightforward. It's super complicated and I consider myself to be educated. I had to help people through this." (29 yrs., suppressed) "You have to renew it like every six months and they don't call you and tell you nothing. They give you a little sticker and if you are not constantly looking at it and it expires, and you don't get in before that period, you have to go through the whole process. If you miss your deadline, you have to just like reapply all over – and that's a longer process." (37 yrs., lost suppression) "Usually when I'm taking the medicine and I'm feeling better, I miss the appointment. But on the doctor's end, if they haven't seen me, and they don't have any blood or anything to go by, I have to see them all over again, and kind of go from the beginning so I can be able to get my refills. So by the time I get to the end of my medicine, I'm going to have to miss some days because my appointment [process of regaining RW eligibility] is two weeks long. So I'll have to redo this stuff every six months." (33 yrs., unsuppressed)
	Social Service Policies	"Back in September when I had my first surgery, I was approved for Medicaid. And then after you know, your income increases…they dropped me. But they dropped me like right before my second surgery, so I had to pay full price, out of pocket for my second surgery. That was just insanely expensive as you can imagine. So I don't understand why now I'm in debt, because I needed to live." (29 yrs., suppressed) "So I've been fortunate enough to be able to be on the ADAP program here which is still based on my income, which is why I choose to not take as much work, when I need to stay below a certain paid level so that I can continue to get healthcare. And that's sad but it's true. Now I'm fortunate enough to be a freelance guy…so I can always say, "Hey, you know, pay me under the table", or if I'm working for a company or corporation sometimes I turn down work more often than I like to. Somebody is like "Hey, here is money", and I'm like "No, that's okay". Like who wants to say that? But I know there it's a fine line between I would rather make less money and make sure that I get my medication every month, than make a couple of hundred dollars extra a month and I have to pay out of pocket $2000. So it's like I choose to be impoverished. It's - excuse my language, fucked up. It really is." (29 yrs., suppressed) "I've got offers at other places, San Francisco and D.C, but the cost of living is so high in those places, it's like I might be better – staying in Atlanta and figuring it out. Not to mention what I had to go through to get set up with the program here, I don't want to have to do that again somewhere else. Yeah, because navigating the healthcare system is different in every state." (29 yrs., suppressed) "Like I went and got Obamacare. I was able to fill my prescription at the CVS for one time and then when I went to go do it the second time, they were saying that I need to pay like $2,500…I just wasn't able to get my medicine.

		Like I couldn't afford it. And then so when I came here to the ADAP to try to re-register, the computer systems in here would show that I had [private] insurance. So I had to get a cancellation letter from Humana, but with them being on Obamacare, they would allow you not to pay your premium for three months before they cancelled the insurance. And that was like the only way for me to cancel the thing." (31 yrs., unsuppressed) "And before this I was taking Stribild, and I was really liking Stribild, but now that I'm on Triumeq I love it. They switched it because during that period that I was dropped from Medicaid, Medicaid covers one, and then the new program covered another one, which is also stupid. I think that it should be universal." (29 yrs., sustained suppressed)
Clinic Factors	Capacity	"They only got two people down there at these clinics. There is over 5,000 people and a lot of them depends on those programs, so you know she can't call you…so you have to really proactive about your stuff." (37 yrs., lost suppression) "They're setting the appointments three months back and that intervenes with you getting your meds properly because they set your appointments so far back." (34 yrs., gained suppression) "Hopefully, when I got to redo my paperwork, they're not tripping downstairs saying, "Oh, well, you got to redo your paperwork but the next appointment is going to be after your meds stop, so." You know, it's always be bad timing really." (32 yrs., lost-gained suppression) "I mean, I get it because I'm sure they're filling a lot of prescriptions, but I don't know if they need more people or something because like there have been times when my doctor has put in my prescription. She was like, "Okay, I just put it in and you can pick it up around two." And I'll come in at two and it still won't be ready. I have to come back the next day. There had been times where I have called it in three days prior to me even coming to pick it up and it's still not ready and it's so annoying." (28 yrs., gained suppression)
Provider Factors	Relationship/ Support	"After the third doctor I had here, I couldn't take it, I went and found a private doctor, and there was no love…he showed me no nurturing. He literally gave me what I wanted and he got me out of there. So I knew that wasn't where I needed to be because having this, I need to know all the answers." (34 yrs., gained suppression) "So to actually have a doctor where it wasn't like, "Let's take blood and get to it." It was more like, "Hey, how are you doing? How are you feeling?" He was more about, let me see you first mentally as well as physically, and then we'll get to the other stuff. And I think it's important to find a doctor and somebody working in healthcare that has the ability to realize that health is two-fold. It's not just physical. I can't just prescribe you medication. If your mental health isn't together, you're not going to properly take your pills in your regimen anyway." (29 yrs., suppressed) "And I thought the doctor gave the support that a father would give a child. He gave me his personal cell phone number. He would let me know that if there was anything that I needed or wanted, to pick up the phone and call him. And I was dealing with a lot at that time, I was ready to let go. He convinced me, you know that it was a

		brighter day, it was a brighter tomorrow. He gave me hope and I took that and I embedded it within me and it brought me to where I needed to be." (34 yrs., gained suppression) "So I never really had like a connection with my doctors and the nurses, and like even now here, it's not that I don't feel like I could get quality care, it's more of like I have no emotional connection to my doctors and nurses. And so, I feel like if I did have one, I would take my medicine more and stuff like that. It would definitely have motivated me to get better test results you know." (31 yrs., unsuppressed)

DISCUSSION

Summary

Using Andersen's Behavioral Model (ABM), we identified a total of 15 themes (mapped to six different ABM domains) operating at multiple levels, that impacted access and adherence to ART among HIV-positive YBMSM engaged in care. Our findings build upon previous research that utilized ABM to explore factors related to HIV continuum of care indicators, by introducing five new themes: resiliency/goals and ambitions, alternative therapies and health beliefs, drug resistance, Ryan White (RW) renewal policies, and social service/health insurance policies and navigation.

Previous studies have found that those who are less resilient have a greater likelihood of engaging in high risk behaviors, including substance use and CAI.[247,248] Although researchers have hypothesized that resiliency would impact adherence in the same way, few studies have demonstrated any correlation between resiliency and ART adherence.[249] Findings from this study indicate that YBMSM's resiliency, determination to adhere to treatment regimens, and will to live was largely influenced by two things: 1) their social support network, and 2) whether or not they set specific life or career goals for themselves. Persons living with HIV/AIDS can benefit from strong social support networks through material (e.g., transportation, housing) or financial support.[200,201] Participation in HIV-positive social support groups can provide PLWHA opportunities to 1) share their struggles with those who had experienced similar hardships, 2) destigmatize/normalize HIV, 3) interact with healthy and successful role models, and 4) obtain knowledge regarding effective treatment options and methods to navigate social relationships.[201,209,233,250,251]

Although YBMSM directly benefitted from their social support network in many ways (emotional, material, and financial), they were also motivated to maintain adherence in order to shield their loved ones from the pain and suffering that would come about from the deterioration of their health. In this instance, participants did not receive any tangible goods, services, or support from their network members, yet still indirectly benefitted from their presence. We also found that YBMSM who had set out concrete goals in their lives (e.g., raise a family, excel in their career) maintained high levels of adherence, confirming results from prior studies.[213,233,252]

Despite their relatively young age, many YBMSM in this study were in advanced stages of disease, experienced multiple bouts of virologic failure and drug resistance, and recently lost health care coverage. Our findings suggest that YBMSM can benefit from interventions that help expand their social support network. Interventions that promote serodiscussion or improve disclosure skills may have the potential to minimize poor health outcomes (e.g., drug resistance, opportunistic infections) and improve YBMSM's access and adherence to ART.

Even though no such evidence of their safety or efficacy exists, PLWHA have increasingly turned to using complementary and alternative medicine (CAM) because of their belief that it can effectively treat HIV infections, minimize medication-related side effects, and improve their overall health and well-being.[253,254] Use of alternative therapies among PLWHA have steadily increased over time, with studies showing a high prevalence (60%) of use in the United States.[254] Two studies found that CAM use was higher among seropositive African-Americans compared to other race groups.[303,304] In this study, YBMSM used CAM as a substitute for ART, believing these therapies could effectively treat HIV. Previous studies have found that CAM use was associated with suboptimal ART adherence.[253,254] Young Black MSM who may be unaware of the dangers related to intermittent adherence, or are negatively impacted

by HIV-related stigma (e.g., taking ART may either remind them of their HIV diagnosis, or may inadvertently reveal their serostatus to others), may see alternative therapies as a viable treatment. The high rate of health care coverage losses may also contribute to the high prevalence of CAM use within this population. Young Black MSM may use alternative therapies as a temporary substitute for ART until they are able to regain access to HIV care services.

It is estimated that anywhere from 3-26% of treatment-naïve, PLWHA in the United States have some form of primary (transmitted) HIV drug resistance.[255-260] Two studies focusing on the general HIV-positive population in the U.S., found that anywhere from one-half to three-quarters of their treatment-experienced samples showed evidence of secondary drug resistance, which occurs when ART fails to suppress the HIV virus.[256,261] We found a similarly high prevalence (76%) of secondary drug resistance among YBMSM (Table 4.1). The high rates of drug resistance may be explained by the fact that YBMSM were in the late stages of disease (80% were diagnosed with AIDS), and greater than 80% had been living with HIV/AIDS for five or more years at the time of the interview (Table 4.1). Previous studies have found that those diagnosed with AIDS are more likely to acquire multiple drug resistant strains of HIV.[263,264] Another study found that drug resistance occurs more frequently in individuals who initiate therapy later in the course of infection compared to those who initiate ART earlier, suggesting that YBMSM in this study may have been diagnosed in the late stages of disease.[262] Studies have shown that Black MSM are more likely to receive a late diagnosis (e.g., received an AIDS diagnosis within 3 months of their HIV diagnosis) compared to White MSM.[305,306]

The development of HIV drug resistance and its effects on ART adherence was a prominent theme in this study. Young Black MSM who were careless with earlier, simpler regimens had to deal with increasingly complex therapies requiring a greater number of pills and

more frequent dosing schedule. These complex regimens made it more difficult for participants to successfully incorporate their medication schedule into their daily routines, and increased the likelihood they would experience severe side effects and medication fatigue. Numerous studies have found that high pill burdens can result in increasingly complex regimens, contributing to treatment fatigue and poor adherence.[200,208,210,233-236] For some YBMSM, the threat of future drug resistance and related consequences (e.g., accelerated progression of disease) motivated them to strictly adhere to their current treatment regimens. For others, repeated occurrences of virologic failure compounded their ability to adhere to ART, and limited their treatment options.

If YBMSM were more likely to be diagnosed late within the course of infection, at a time when their health is failing, they may not have the option to delay initiating ART, even if they're not ready to adhere to daily medication regimens. Structural interventions that expand access to HIV testing services among YBMSM may not only reduce levels of undiagnosed infection, but can also improve rates of early diagnosis within this population. Strategies that increase rates of HIV testing among MSM include social network based strategies (e.g., recruiting peers from a participant's social network to test for HIV), community-based strategies (e.g., mobile HIV testing units, community-based clinics), and HIV self-testing kits.[307] Although rates of HIV testing among Black MSM and YBMSM have recently increased, effective strategies that improve early diagnosis of HIV are lacking for this population.[308]

An important theme that had not been previously explored in depth was the effect social service program policies had on YBMSM's access to ART. Participants indicated that the frequent (every six months) RW renewal requirement was a major factor contributing to their loss of health care coverage and subsequent viral instability, echoing findings from previous studies.[265-267] Almost two-thirds of participants reported receiving HIV-related care and

medications at no cost through Georgia's (GA) RW program (Table 4.1).[265] A high percentage (72%) of YBMSM, lost RW coverage within one year of their interview date, cutting off access to critical HIV care services and medications (Table 4.1). This far exceeds the rate of RW coverage lapses (39%) found in GA in 2015, and is in line with documented racial disparities in important HIV care continuum indicators (e.g., retention in care, ART access/adherence).[11,15,104-106,241,268] Additionally, the high rate of coverage lapses mirrored the high proportion of participants who had ever developed secondary drug resistance, supporting the idea that inadequate engagement and retention in care likely increases the risk of secondary drug resistance. (Table 4.1).[269]

Young Black MSM experienced a significant amount of churning in this study, moving back and forth from RW to Medicaid to the private insurance marketplace. Differing income eligibility requirements for public health care programs such as Medicaid and RW, combined with unstable incomes contributed to YBMSM's loss of coverage. As incomes of PLWHA fluctuate over time, the population is at risk for cycling in and out of health care programs.[239] It is estimated that almost 31% of individuals receiving Medicaid or subsidies in the health insurance marketplace change their health care coverage on an annual basis.[271] Among PLWHA attending a RW-funded clinic, those who were financially unstable were more likely to have gaps in their health care coverage.[241] Other health insurance/social service program policies including mandatory minimum cancellation periods and differing medication formularies limited YBMSM's access to care, and created further barriers to treatment adherence. Sudden changes to medication regimens (due to differing formularies) may facilitate suboptimal adherence if the new regimen is more complex or comes with severe side effects.[271]

Another important finding from this study was the identification of key themes that impacted treatment access and adherence through multiple pathways. The one theme that was a common factor in many YBMSM's struggles to obtain and adhere to ART was stigma/coping. In many cases, participants' propensity to internalize stigma and practice negative coping strategies indirectly influenced their health behaviors through pathways involving numerous other themes. For instance, participants who did not have the ability to effectively cope with their diagnosis were less likely to disclose their HIV status to others, limiting their ability to expand their social support network, while also creating a living arrangement (with roommates who were unaware of their HIV status) not conducive to maintaining effective adherence levels. Similar pathways involving stigma, disclosure, and social support and their effects on ART access/adherence have been documented in the literature.[200,201,209,250] Stigma and social support were two of the most commonly reported barriers to treatment access and adherence in this study (Figure 4.4).

Some YBMSM who had difficulties coping with their diagnosis reported depressive symptoms during the timeline period. These participants lacked the motivation to regularly seek their health care provider or adhere to their treatment regimens. Stigma has previously been found to be an important predictor of depression.[203,272] Mental health was also a prominent theme, with over one-third of participants reporting it as a barrier to ART access and adherence (Figure 4.4). Young Black MSM who reported engaging in harmful coping strategies (e.g., denial, disengagement) were more likely to have false perceptions about their health, experience medication fatigue, and were more likely to substitute (or delay taking) their ART regimens with alternative therapies. Previous studies found that participants who used CAM believed they could manage their illness solely using alternative therapies, thereby avoiding the label and stigma associated with a HIV-positive status; or that PLWHA who felt "healthy", remained in a

state of denial, reinforcing their belief that they did not have HIV.[273,274] The pathways described above represent few of the many mechanisms by which stigma/coping worked to affect YBMSM's access and adherence to ART.

Strengths and Limitations

Although there are substantial race and age disparities in HIV continuum of care indicators, relatively little is known about the factors impacting poor or successful navigation through the treatment cascade for HIV-positive YBMSM.[109,118,275,276] A few studies have identified individual-level factors (socio-demographic characteristics, sexual behaviors, psychosocial factors) related to negative treatment outcomes (ART access/adherence, viral suppression) among young, HIV-positive MSM.[118-121] Our study was unique in that it concurrently identified individual (e.g., mental health, stigma), dyadic (e.g., social support, provider relationship), and structural (e.g., health care policies, housing, employment) factors affecting treatment access and adherence among seropositive YBMSM. Previous qualitative studies utilizing ABM have focused on broader populations in their samples, including both males and females, heterosexuals and MSM, patients of all age ranges, and even clinic staff and providers.[200,224]

To our knowledge, this is the first mixed methods study to connect themes related to ART access and adherence to clinical outcomes (VL status, drug resistance) abstracted from medical records, and sexual behaviors that occurred over the same timeframe. We found a high degree of correlation between participants' viral status and the proportion of total themes that acted as barriers or facilitators, providing some evidence that these themes do in fact play an important role in YBMSM's treatment access and adherence. Participants with suppressed VL reported low rates of status disclosure and high rates of serodiscordant CAI, whereas those with

unsuppressed VL reported high rates of disclosure and low rates of serodiscordant CAI. These findings suggest that unsuppressed YBMSM may have been aware of their viral status and accordingly, took actions to reduce their risk of transmitting HIV to others. Two other studies found the opposite result: those with detectable VL were more likely to engage in CAI.[121,277]

There are a few limitations to this study. Because we purposively sampled a small number of HIV-positive YBMSM attending a RW-funded clinic in Atlanta, GA, our study findings may not be generalizable to the larger community of HIV-positive YBMSM, those attending a different clinic, or populations from other parts of the country. Future studies should explore factors related to linkage to care, and ART access and adherence among newly diagnosed (treatment-naïve) YBMSM, since their experiences may differ from those who have already initiated ART. As part of the study eligibility criteria, our study population was technically retained in care, even though over three-quarters of the sample had lost health care coverage recently. Definitions incorporating information on health care coverage renewal rates, frequencies of missed clinic visits, or extending the time period from which retention is measured may better differentiate those retained in care vs. those who have fallen out of care.[241,278] Our study findings may be more relevant to the HIV-positive, YBMSM patient population that struggles to stay engaged within the system of HIV care. The qualitative nature of this study inhibits us from making any statistical inferences about this population. Quantitative studies are needed to test the relationships between the themes identified in this study and behavioral/clinical outcomes.

Public Health Importance

Currently, there are few efficacious interventions designed to improve HIV-positive YBMSM's care continuum outcomes.[117] A systematic review found that out of 12 interventions

targeting Black MSM, eight sought to reduce sexual behaviors, and only three were designed to improve rates of linkage to, and retention in care.[279] According to the CDC's compendium of evidence-based interventions (EBI), among 14 interventions whose goals are to improve linkage, retention, and re-engagement in HIV care, two targeted young, seropositive Black persons, and only one of the two was designed for YBMSM.[280] Among the 14 EBI found to improve medication adherence, only one targeted young PLWHA.[116] The lack of effective interventions developed for HIV-positive YBMSM indicates a need for further research to identify factors influencing this group's navigation through the HIV continuum of care.

This study identified numerous themes that can be used to inform the development of multi-level interventions that improve HIV-positive YBMSM's access and adherence to ART. A commonly reported barrier to YBMSM's treatment access and adherence was HIV-related stigma/coping. HIV-related stigma that is experienced at the individual-level indirectly affected YBMSM's access and adherence to ART through other individual-level domains (e.g., mental health, perceived health, alternative therapies). For example, YBMSM who were prone to internalize stigma, often had a negative self-image of themselves and suffered from depression, lacking the will to adhere to their treatment regimen or attend their medical appointments. Young Black MSM who were in a state of denial (e.g., taking ART reminded them of their positive HIV status), used their perceived "healthy" status (i.e., lack of physical symptoms) as an excuse to stop taking ART altogether, or replace them with alternative therapies.

Individual-level behavioral interventions that teach positive coping skills (e.g., status disclosure strategies) or increases YBMSM's sense of self-worth (i.e., improved self-esteem) may facilitate ART access and adherence by minimizing the effects of other individual-level treatment barriers such as depression.[313,314] Although studies have shown that individual-level

behavioral interventions are effective at reducing levels of stigma among PLWHA, few studies have evaluated the influence of stigma reduction interventions on HIV-related health outcomes (e.g., ART adherence).[311,313,314] The Healthy Living Project was a 15 session, individually-delivered, cognitive behavioral intervention conducted among PLWHA in 4 U.S. cities.[310] One of the intervention components included a module addressing psychological coping and skills to develop positive supportive social relationships.[310] Although the intervention group saw significant improvements in adherence levels compared to the control group, these differences were non-existent at follow-up.[310]

Young Black MSM who experienced rejection and discrimination from family members and friends (i.e., stigma experienced at the dyadic level) because of their HIV status also struggled with depression (individual-level factor) and poor adherence. As a result, YBMSM were reluctant to disclose (dyadic factor) their HIV status to others, fearing further rejection. This limited their capacity to receive emotional and material support from their social support network (dyadic factor). Studies evaluating the effectiveness of social support interventions on increasing adherence levels have been inconclusive.[312] Two dyadic interventions that employed peers to provide emotional and informational support to study participants found no differences in VL levels or ART adherence between the intervention and control arms at follow-up.[317,318] In contrast, another study found increases in retention in care and ART adherence when both HIV-positive YBMSM and an existing social support network member were educated on the importance of maintaining high levels of adherence, and collaboratively worked together to problem solve potential barriers to adherence (dyadic intervention).[117] Although social support interventions should be expected to improve ART adherence, the potential positive effects of these interventions may only exist among PLWHA who are immune to the negative effects of

stigma (e.g., those who have low levels of internalized stigma, practice positive coping strategies, or are able to disclose their status to others).[250,312]

Interventions that do not include elements addressing fundamental (higher order) causes (e.g., stigma/coping) of ART access and adherence may not find an effect (e.g., increases in adherence levels), even if the intervention is efficacious in changing behaviors (e.g., increases in social support) further down the causal pathway.[312] Previous studies have used structural equation modeling to describe the hierarchical pathways and connections between multiple factors, and their association with ART adherence.[205,281] In one study, the authors found that PLWHA's inability to acquire basic needs (structural factors) such as housing, food, and transportation made it more difficult to access dyadic supports (social support), and also lowered their treatment self-efficacy (individual-level factor), contributing to poor adherence.[205] Two other studies found that depression (individual-level factor) partially mediated the relationship between stigma and adherence.[281,315] These studies suggest that intervening at earlier stages within the pathway (e.g., providing affordable housing, teaching effective coping skills) may have a larger impact on increasing access and adherence to ART.[205,281,315] Future studies should utilize a hierarchical framework to identify and rank factors by their potential impact on improving health behaviors and care continuum outcomes of HIV-positive YBMSM. These studies may validate our findings that highlighted HIV-related stigma/coping as a central theme involved in many pathways affecting YBMSM's access and adherence to ART.

The processes and mechanisms by which HIV-related stigma impacts treatment access and adherence are inherently multi-dimensional in nature (occur at multiple levels).[309,315] Different domains of stigma include: 1) negative self-image, which includes feelings of shame and guilt (individual-level), 2) personalized stigma, which measures the perceived consequences

of other people knowing one's HIV status (individual-level) 3) concerns regarding status disclosure (dyadic), and 4) public attitudes towards HIV/social norms (structural).[309,315] In this study, YBMSM experienced stigma at the individual-level (e.g., feelings of shame, denial, fear of rejection, internalized stigma), at the interpersonal/dyadic-level (e.g., rejection and discrimination), and at the structural-level (e.g., community attitudes towards HIV within Black gay community). Similar to previous studies, HIV-related stigma operated at multiple levels, within complex pathways involving other multi-level domains of influence, to impact YBMSM's treatment access and adherence.[311,312,315]

Interventions that target reductions in stigma at multiple levels, combined with interventions addressing other important multi-level factors, will likely have the greatest impact at improving YBMSM's health behaviors.[309,311,312,315] In this study, YBMSM did not have the financial means to secure stable housing, adequate nutrition, or meet other basic needs. Even if levels of stigma were reduced within this population, structural barriers to ART access and adherence may remain. The lack of a consistent effect found in interventions targeting only individual-level or dyadic processes, may be explained by the fact that these interventions fail to address the larger structural forces undermining ART access and adherence.[312]

Findings from this study underscore the importance of developing combination HIV prevention strategies that target multi-level factors affecting YBMSM's access and adherence to ART. However, multi-level prevention strategies are rarely employed. In a systematic review evaluating stigma-reduction interventions, 85% of all studies intervened at a single socio-ecologic level, and individual-level interventions were by far the most common.[311] Individual-level interventions that teach effective coping strategies (e.g., positive reappraisal, active coping, seeking social support) in tandem with efforts to reduce HIV-related stigma within the

community (structural) may yield significant improvements in health seeking and health management behaviors of HIV-positive YBMSM.[228-230,282] One study found reductions in levels of stigma, and increases in HIV testing rates after the implementation of a community-based HIV awareness and educational campaign (information delivered at the individual-level), and the passing of legislation (structural) expanding the availability of ART.[316]

Structural HIV prevention interventions often attempt to change the environment in which health-related behaviors occur, and have the potential to reach a larger population base.[45] These interventions may include changes to policy or laws (e.g., policy requiring the use of condoms in brothels in Thailand), cultural or social norms (e.g., improving gender equitable behaviors), or environmental factors (e.g., availability of stable housing) that serve as the foundational structures that shape individual HIV risk.[45,46] However, few structural interventions targeting young African-Americans, young MSM, or YBMSM exist.[52] In this study, we identified opportunities for changes to policy that may help reduce health care coverage lapses and improve access to HIV medications.

Young Black MSM specifically noted that frequent RW renewal requirements and differing income eligibility limits across social service programs contributed to gaps in their health care coverage. Various solutions proposed to reduce the amount of churning experienced by low income adults include expanding income eligibility requirements and extending coverage lengths (reducing the frequency of required renewals).[270,283] One study found that extending Medicaid eligibility either to the end of the calendar year or for 12 months after enrollment could potentially reduce lapses in health care coverage.[283] Expansion of Medicaid income eligibility requirements could also reduce the amount of churning experienced by low income YBMSM. As of June 2018, 17 states including Georgia have opted not to expand Medicaid, leaving most low

income PLWHA in these states ineligible for Medicaid services, and more likely to seek episodic care at the emergency department or free clinics.[239,284] Low income PLWHA will only be eligible to receive Medicaid services once they become disabled (in states that opted out of Medicaid expansion), at which point their health will have deteriorated, incurring increasingly high costs of treatment.[239] In this study, YBMSM often experienced gaps in their health care coverage, restricting their access to HIV care services and ART. Structural interventions that incorporate youth-specific services (e.g., youth-focused case managers or social workers) into existing standards of care can help YBMSM navigate their way through potential administrative barriers so that they remain engaged and retained in care.[114,115]

Conclusion

We identified numerous themes at multiple levels (individual, dyadic, structural) affecting access and adherence to ART among HIV-positive YBMSM engaged in HIV care in Atlanta, GA. HIV-related stigma was involved in many complex pathways limited YBMSM's access and adherence to ART. We also observed YBMSM who were repeatedly stuck in negative feedback loops that affected clinical outcomes (e.g., drug resistance, virologic failure), and further hindered their ability to adhere to their treatment regimens. Overall, those who reported multiple barriers to treatment access and adherence exhibited unstable viral load levels, but also engaged in protective behaviors that decreased their risk of transmission to others. Findings from this study can be used to inform the development of multi-level HIV prevention interventions that minimize the transmission risk of YBMSM. Further research focusing on this understudied population at high risk for both poor health outcomes and HIV transmission, is needed to identify new (multi-level) domains of influence, validate the connections between

existing domains, and characterize the potential impact these domains may have in facilitating successful movement through the HIV continuum of care.

CHAPTER 5. CONCLUSIONS AND PUBLIC HEALTH IMPLICATIONS

Overview of Dissertation

The purpose of this dissertation was to identify multi-level (individual, dyadic, structural) factors associated with HIV infection and transmission risk among YBMSM residing in Atlanta GA. Young Black MSM are at high risk of becoming infected with, transmitting, and dying from HIV/AIDS.[7,110,111,285] Despite their disproportionate burden of disease, there has historically been a lack of research on, and development of effective HIV prevention interventions targeting YBMSM.[286]

No single HIV prevention intervention on its own is likely to have a significant impact on reducing HIV transmissions in the United States.[35] In order to maximize the effectiveness of HIV prevention strategies, efforts to reduce the susceptibility among those without infection, should be coupled with efforts to reduce the transmissibility of those living with HIV/AIDS.[35] Given the limitations of individual-level behavioral interventions in reducing HIV incidence, and the lack of evidence connecting racial disparities in HIV to differences in individual-level sexual behaviors, prevention efforts should target multiple HIV risk factors, and intervene at multiple levels, to bring about significant reductions in HIV transmissions.[8,31,39]

This dissertation fills in important gaps in the YBMSM HIV research literature. In Aims 1 and 2, a latent measure of HIV risk perception was developed and used to evaluate the relationships between perceived risk and both past and future behaviors (known to increase vulnerability to HIV infection) among HIV-negative YBMSM residing in Atlanta, GA. Individual-level and dyadic (partner-level) factors associated with sexual behaviors were identified in these two aims. In Aim 3, we explored themes related to ART access and adherence

(that directly impact the risk of HIV transmission) among HIV-positive YBMSM engaged in care in Atlanta, GA. Individual, dyadic, and structural factors that facilitated or hindered treatment access and adherence were identified in Aim 3. In this chapter, we review the major findings and innovations that came from this dissertation. We also discuss the public health implications of our findings, and provide guidance for future research in this area of interest.

Review of Major Findings

In Aim 1, we developed a novel measure of HIV risk perception using latent class analysis. Sixteen questions conditional on individual-level sexual behaviors (condom use, sexual position) and dyadic partner-characteristics (partner HIV status, ART use/viral suppression) were used to construct four typologies of perceived risk. These four typologies were validated against 11 sexual and non-sexual measures. Two typologies: low perceived risk and status-derived risk perception were found to have moderate to strong associations with both sexual behaviors and non-sexual correlates. In this aim, we observed that perceived risk measured at the individual-level (though conditional on both individual and dyadic characteristics) correlated with individual (e.g., negative condom attitudes) and dyadic (e.g., any sex with HIV-positive partner) outcomes.

In Aim 2, we utilized the latent measure of HIV risk perception developed in Aim 1 to evaluate the associations between perceived HIV risk with both past and future sexual behaviors. In independent models, we found some evidence (in two risk perception typologies) to support a continual causal framework in which previous behaviors inform current risk perception (reflective hypothesis), which then helps to predict future behaviors (motivational hypothesis). Low risk perceivers engaged in protective behaviors both at baseline (less sex with status unknown partners) and at follow-up (less sex with status unknown partners, less CAI among

Black MSM, greater awareness of partner status). Status-derived risk perceivers were less likely to report sex with a HIV-positive partner at baseline, and less likely to report CAI with a HIV-positive partner at follow-up.

We also found that the effect of perceived risk on behaviors differed by factors at the individual-level by race, and at the dyadic-level by partner HIV status. Typologies of perceived risk elevated rates of CAI among Black MSM, but not White MSM. And low risk perceivers increased levels of partner status awareness among White MSM, but not Black MSM. Our results suggest that HIV-negative YBMSM who don't have a low perception of risk may benefit from individual-level interventions that promote condom use. Risk compensation by race was also evident. Black MSM were less likely to engage in CAI and less likely to be aware of their partner's status. White MSM were more likely to engage in CAI and more likely to be aware of their partner's status.

In Aim 3, we used a mixed-methods approach to explore themes related to ART access and adherence among patients with four different VL experiences. Young Black MSM's struggles with HIV-related stigma was a central theme that impeded their access and adherence to ART through multiple pathways. Young Black MSM experienced stigma at multiple levels, which indirectly impacted their treatment access and adherence through other factors at the individual, dyadic, and structural levels. The repeated development of drug resistance (individual-level) was especially harmful for YBMSM whose earlier struggles with adherence were compounded by increasingly complex medication regimens (structural). A high prevalence of secondary drug resistance (individual-level) mirrored the high rates of health care coverage lapses (structural) experienced by participants during this timeframe. The frequent RW renewal requirements along with differences in income eligibility requirements across social service

programs (structural) contributed to these gaps in coverage. Overall, YBMSM who reported a higher frequency of themes that served as barriers to ART access/adherence had difficulties suppressing their VL levels compared to those who reported a higher proportion of themes that served as facilitators. However, those with unstable VL took action (engaged in fewer high risk sexual behaviors) to protect their sexual partners against HIV transmission. Results from this aim identified multiple domains of influence that can be used to develop multi-level HIV prevention interventions targeting YBMSM. Additionally, our findings suggest that specific domains (e.g., HIV-related stigma) may be more relevant to, and have a greater impact on improving the health behaviors of YBMSM.

Innovations

This dissertation presents a number of innovations with respect to research focusing on YBMSM's HIV infection and transmission risk. Findings from studies evaluating the effect of perceived HIV risk (i.e., one's belief or perceived likelihood of becoming infected with HIV) on sexual behaviors (e.g., CAI) have been inconclusive. Previous studies have found both increases and decreases in condom use associated with higher levels of risk perception.[76-79] Experts have surmised that the poor measurement of HIV risk perception likely contributed to inconsistent results.[80,133] Many studies used a single, unconditional question to measure perceived risk.[133-135,138] A single question is likely inadequate in capturing the multiple, complex pathways by which YBMSM perceive their risk of HIV infection.[131,134,135] Because risk perception can vary by individual-level (e.g., demographics) and dyadic factors (e.g., partner characteristics, sexual behaviors), the use of unconditional questions that do not tie an individual's perceived risk to these multi-level factors are not recommended.[76-80,131,133,138,139,146-149,150-153]

In Aim 1, we developed a latent measure of HIV risk perception using 16 questions conditional on sexual behaviors (sexual position, condom use) and dyadic, partner characteristics (partner HIV status, ART use/viral suppression). Latent class analysis allowed us to identify subgroups of participants that exhibit similar patterns of risk perception. The typologies of perceived risk differentiated young MSM according to how safe or risky they considered certain combinations of sexual activities or partner types were. The latent measure may be a better representation of the way young MSM think about their perceived risk of HIV infection (and a better predictor of behaviors) compared to the ordinal measures (categorized from Likert scales) used in most studies.[133,138,142] Individuals have a difficult time objectively making judgements about their risk of HIV infection, which itself is a low probability event, on a numeric scale.[80] To our knowledge, this is the first study to utilize questions conditional on multi-level factors to construct a latent measure of perceived HIV risk.

The common use of cross-sectional study designs, analyses conducted at the individual/participant-level, and inadequate control of important multi-level confounders also contributed to contradictory findings for the relationship between HIV risk perception and sexual behaviors. Because temporality cannot be established using a cross-sectional design, it is difficult to determine whether study results are relevant to the hypothesis that past behaviors inform perceived risk, or pertain to the notion that perception of risk predicts future behaviors.[132,134,145,146] This study is one of the few that utilized a longitudinal design, establishing temporality between the exposure and outcome(s), and allowing us to test both hypotheses separately, within the same study population.

Dyadic (partner-level) factors such as a partner's HIV status and the type of partnership (e.g., main vs. casual) are associated with HIV risk perception and sexual behaviors.[79,80,132,146-

[148,172-174] A clear majority of studies conducted individual-level analyses that summarized the potentially different effects (of perceived risk on behaviors) across all partners. However, perception of risk can vary from partner to partner.[79,146] In Aim 2, we controlled for dyadic factors (partner type, partner HIV status) and conducted analyses (using partner-level outcomes) that allowed us to evaluate the perceived risk-sexual behavior association at the partnership level.

Racial differences in the effect of perceived risk on sexual behaviors may provide further insight into racial disparities in HIV. This is the first study to have assessed whether the association between HIV risk perception and sexual behaviors differed between Black and White MSM. We found that non-low risk perception typologies elevated rates of CAI among Black MSM, and the low risk perception typology increased levels of partner status awareness among White MSM. We will discuss the implications of these findings in the next section.

Aim 3 is the only study to have concurrently identified individual, dyadic, and structural factors influencing YBMSM's access and adherence to ART. Previous studies have focused on broader MSM populations or identified a narrow set of factors associated with successful navigation through the HIV continuum of care.[118-121,200,224] We were able to identify five new themes related to ART access/adherence that had previously not been mapped to ABM. One of the unique findings from this study was the effect health care policies (e.g., income eligibility limits, program renewal requirements) had on YBMSM's access to HIV care services and ART. This is the first study to explore how structural policies impacted YBMSM's health behaviors, and provides an opportunity to inform the development of future policy that has the potential to keep large groups of YBMSM retained in care. In addition to the qualitative exploration of themes, quantitative data was collected to both validate and provide further context to the qualitative findings. Qualitative themes related to ART access and adherence were connected to

clinical outcomes (abstracted from medical records), and sexual behaviors (obtained via self-report) that occurred over the same timeframe. Few studies have investigated the connection between VL status, sexual behaviors, and factors related to ART access and adherence among YBMSM.[121,136,277]

Relevance and Public Health Impact

Results from this dissertation can be used to guide the development of multi-level HIV prevention strategies targeting both seronegative and seropositive YBMSM. We demonstrated the utility of a latent measure of HIV risk perception that was correlated with past behaviors, and predicted future behaviors. For instance, we found that participants whose perceived risk was largely influenced by their partner's HIV status, were less likely to report CAI with HIV-positive partners, but more likely to report CAI with status unknown partners during follow-up. Although these participants may believe they're protected by using condoms when having sex with HIV-positive partners, they remain at risk for infection from partners whose status they are unaware of.

The integration of latent measures of perceived risk within current risk assessment tools may identify YBMSM at high risk for HIV infection. Lengthy risk assessments can create barriers to HIV testing, and the data obtained from these risk assessments have been found to be inaccurate.[82,83] A shortened tool incorporating latent measures of perceived risk may better discriminate high-risk YBMSM compared to current HIV risk scores. HIV risk scores developed for MSM populations were derived and validated from study samples that were overwhelmingly White, calling into question their utility in identifying YBMSM vulnerable to infection.[56-58] One study found that each risk score had a substantially lower sensitivity in predicting later seroconversion among Black MSM when compared to White MSM.[61] These tools can be used to

efficiently allocate limited HIV prevention resources to those individuals at greatest risk for infection. Additionally, the latent typologies can maximize the effectiveness of multi-level, behavioral interventions by matching the behavioral effect of the intervention (e.g., increase in partner status awareness) to the typology that would most benefit from that effect (e.g., status-derived risk perceivers who are more likely to engage in CAI with status unknown partners). For example, status-derived risk perceivers who are more likely to engage in CAI with status unknown partners may benefit from dyadic interventions designed to improve serodiscussion.

Latent typologies of perceived risk may also affect behaviors differentially by race. In Aim 2, risk perception typologies affected CAI in Black MSM, but not White MSM; and the low risk perception typology influenced partner status awareness in White MSM, but not Black MSM. We also found evidence of risk compensation: Black MSM were less likely to report CAI, but more likely to be unaware of their partner's HIV status compared to White MSM. A previous study found that serodiscussion within CAI partnerships was less frequent among both HIV-negative and HIV-positive Black MSM, when compared to White MSM.[193] Information from this dissertation can be used to tailor interventions to specific groups by race. For example, Black MSM without a low risk perception may benefit from individual-level, behavioral interventions designed to increase condom use behaviors. However, further research is needed to verify that the latent typologies identified in this dissertation are relevant to YBMSM.

In the third aim, we identified numerous themes related to ART access and adherenceth at affects the HIV transmission risk of seropositive YBMSM. Results from this aim can help inform the development of multi-level interventions and combination prevention strategies that facilitate YBMSM's movement through the HIV continuum of care. In this study, many participants reported that HIV-related stigma experienced at multiple levels, obstructed their

access and adherence to ART through multiple mechanisms involving other multi-level domains of influence. Numerous studies have established that HIV-related stigma creates barriers to PLWHA's treatment adherence.[200,201,209,288] However, many of the complex causal pathways that link stigma to adherence difficulties remain undefined.[288] Previous studies have found attenuated associations from multivariate models, because researchers have unknowingly included mediators that reside within the stigma-adherence causal pathway.[288] This dissertation provided further clarification of the specific causal mechanisms by which HIV-related stigma and various coping strategies work with other multi-level factors to affect YBMSM's access and adherence to ART.

Interventions that reduce levels of stigma within the community or improve coping strategies at the individual-level, may have a significant impact on improving YBMSM's health behaviors, moreso than interventions that target factors further down the stigma-adherence causal pathway. Two individual-level, behavioral interventions delivered to HIV-positive men and women included components addressing adaptive coping strategies and achieving positive affect.[287,290] These interventions found reductions in unprotected sex acts with serodiscordant and status unknown partners, and increased adherence levels in the intervention arm compared to the control arm.[287,290]

Interventions that target different HIV risk factors operating at multiple levels, will likely have the greatest impact at improving YBMSM's access and adherence to ART.[309,311,312,315] Two dyadic interventions designed to increase both emotional and informational social support found no differences in adherence between the intervention and controls arms at follow-up.[317,318] Although one of these interventions found greater levels of self-reported adherence immediately post-intervention, these effects were not maintained at follow-up.[318] In contrast, two other

dyadic, behavioral interventions elicited existing social support network members to collaboratively problem-solve potential barriers to treatment adherence.[117,289] These two studies found improvements in ART adherence and retention in care among the HIV-positive participants who received the intervention, compared to those who did not.[117,289] The lack of a consistent effect found in individual-level or dyadic interventions may be explained by the fact that these interventions fail to address the underlying, structural causes of poor adherence and limited access to ART.[312]

Structural interventions play an essential role in bringing about sustained behavioral change, and long-term, population-level reductions in HIV transmission.[39,50] Results from Aim 3 can be used to inform the development of structural interventions that minimize gaps in YBMSM's health care coverage. Many HIV-positive YBMSM lost health care coverage during the study period due to a combination of frequent RW renewal requirements and differing income eligibility limits across various social service programs. Policies that expand income eligibility limits and lengthen health care coverage periods may reduce the high frequency of churning experienced by YBMSM.[270,283]

Findings from this dissertation can be used to inform the development of multi-level interventions that decrease the risk of infection among HIV-negative YBMSM, and minimize the risk of transmission among HIV-positive YBMSM. Latent typologies of HIV risk perception may be able to identify YBMSM at high risk for HIV infection, and match them to the individual-level or dyadic intervention they would benefit most from. Interventions that reduce HIV-related stigma at multiple-levels, or structural policies that minimize lapses in health care coverage can improve ART access and adherence among seropositive YBMSM. There should be

a greater emphasis placed on the development of multi-level HIV prevention strategies that can reduce the disproportionate burden of infection experienced by YBMSM.

Future Directions

Numerous research questions were generated from this dissertation that should guide the future of research focused on identifying multi-level factors associated HIV infection and transmission risk among YBMSM. In the first aim, we utilized LCA to construct four typologies of HIV risk perception from a sample of young White and Black MSM. However, the typologies constructed from this sample may differ from the ones constructed using a sample of only YBMSM. Results from Aim 2 suggest that an ordinal (high/low) categorization of perceived risk may suffice for Black MSM, since the magnitude of effect estimates were similar across non-low risk perception typologies (Class 2, 3, and 4) for the CAI outcome. Future studies should assess whether these same typologies of perceived risk exist in a sample of YBMSM.

Factors at the individual-level (condom use, sexual position) and at the dyadic-level (partner HIV status) were used to construct the latent measure of perceived risk. Future studies should incorporate other multi-level factors to further refine the latent measure. Individual-level factors such as PrEP use, and structural factors including high levels of poverty within the community (or living in a geographic region that lacks adequate health care facilities) would likely increase one's perceived risk of infection, but also affect their propensity to engage in high risk sexual behaviors.

Although we utilized LCA to create a more nuanced measure of perceived risk conditional on sexual behaviors and dyadic, partner characteristics, we do not know whether this latent measure is a better predictor of future behaviors compared to a traditional, ordinal measure. As a sensitivity analysis, we can construct a summary measure of risk perception (sum

up the responses for all 16 individual inputs and dichotomize the score) to evaluate its utility in predicting future sexual behaviors, and compare results from this analysis to the ones found in this dissertation.

In Aims 1 and 2, we utilized a global measure of HIV risk perception that assumes that perceived risk is similar across all partners of the same participant. Because perceived risk can vary from partner to partner (depending on partner-specific traits), future studies should utilize partner-specific measures of perceived risk. Longitudinal studies should also collect multiple measurements of partner-specific risk perception over time to assess how changes in perceived risk within partners affect partner-specific behaviors. Although multiple measurements of behavioral outcomes were collected in this study, we limited our analyses to the first reported outcome during follow-up to minimize the time between the exposure (only collected at baseline) and the outcome.

Changes in the behaviors from baseline to follow-up can further distinguish patterns of sexual behaviors. For instance, an individual who engages in CAI at baseline and at follow-up (with the same partner), is behaviorally different from a different individual who has protected sex at baseline, but engages in CAI at follow-up with the same partner. Although we did not use multiple measurements of the outcome in our analyses (due to limited sample size), future longitudinal studies should collect multiple measurements of both the exposure and outcome, and conduct analyses that account for changes in both covariates over time. A repeated measures, longitudinal analysis would provide stronger evidence of a continual causal framework in which past behaviors inform current risk perception, which then goes on to motivate future behaviors. In this dissertation, we assessed the reflective and motivational hypotheses in separate, independent models.

The potential misclassification of self-reported behaviors (e.g., CAI, partner HIV status awareness) was a major limitation in this study (among many others). Prior studies have demonstrated that HIV-related sexual behaviors are often subject to misclassification because of the stigma attached to these behaviors.[84,85,169] It is unknown whether results indicating racial differences in the rates of CAI and partner status awareness, or differential effects of the latent typologies on sexual behaviors by race, are real, or a product of misclassification. One study found that the misclassification of CAI was much higher in Black compared to White partnerships.[196] Misclassification of a sufficient magnitude could even explain the discrepancy between the high rates of HIV experienced by Black MSM, despite lower levels (of reported) sexual behaviors.[17]

Future studies should develop methods to minimize misclassification of self-reported behaviors. One study recruited both members of sexual partnerships to estimate the concordance of reported behaviors.[196] An accurate estimate of the magnitude of misclassification can be used in subsequent analyses to adjust for potential biases. Instead of using self-reported outcomes that are prone to misclassification, studies can use highly sensitive/specific biological markers such as HIV/STI incidence. The use of biomarkers would require the recruitment of a large sample, and an extensive follow-up period to ensure there are enough outcomes (incident infections) to conduct analyses on.[17] However, inclusion of biomarkers likely excludes partner-level analyses unless the HIV/STI infection can be genetically linked to a specific partner.

Misclassification of our exposure measurement is unlikely to be differential by outcome. Future studies that utilize LCA to construct a perceived risk measurement should take into account the uncertainty of class assignment by multiply imputing latent class membership in their analyses.[156] Questions measuring perception of risk should not be confused with questions

measuring general knowledge of HIV transmission risks. Hypothetical sexual scenarios that were used to measure risk perception in this study may not represent behaviors participants have, or ever will engage in (though they still may rate these events as "risky"). Future studies should ensure that measures of perceived risk reflect participants' feelings or beliefs about their own risk of HIV infection.

Because this was the first study to utilize LCA to create a novel measure of HIV risk perception, findings from this study need to be replicated. Future studies that use similar questions (conditional on sexual behaviors and partner characteristics) and guidelines to construct latent measures of perceived risk should evaluate its utility in predicting behaviors or HIV seroconversion in YBMSM and other high risk populations. Once a standard measure has been developed, subsequent studies can test the sensitivity/specificity with which the risk perception measure predicts various behavioral/biologic outcomes.

Many of the themes related to ART access and adherence identified in Aim 3 have previously been established in quantitative and qualitative literature. One of the more interesting findings in this dissertation was the characterization of complex causal pathways, involving multiple themes operating at multiple levels. We discovered that HIV-related stigma was a commonly reported theme involved in many of the complex pathways affecting YBMSM's treatment access and adherence. Future quantitative studies are needed to verify the existence of these complex pathways and associations. These studies should use a hierarchical framework to describe the connections between multiple factors, and identify those that have the greatest potential impact on improving health behaviors and outcomes. Results from prior studies provide an incomplete picture of these causal pathways, only including a subsample of relevant factors.[205,281,288]

Another unique finding in Aim 3 was the effect structural health care policies had on YBMSM's loss of health care coverage. An exceedingly high percentage of YBMSM had recently lost RW coverage, much higher than the rate of RW coverage lapses seen in all of Georgia. Frequent renewal requirements combined with income eligibility limits contributed to these gaps in coverage. Future studies should characterize levels of churning within this population at high risk for poor adherence. These studies should also evaluate other structural policies that may contribute to poor retention in HIV care.

Although YBMSM in Aim 3 were engaged and technically "retained" in care, many had recently experienced difficulties with maintaining stable health care coverage. Additionally, most YBMSM in this study were in advanced stages of disease, and had been living with HIV/AIDS for a significant amount of time. Consequently, results from this aim may only be generalizable to similar treatment-experienced populations that struggle to stay engaged within the system of HIV care. Future studies should explore factors facilitating successful navigation of the HIV treatment cascade among newly diagnosed (treatment-naïve) YBMSM, since their experiences are likely to differ from those who are treatment-experienced.

REFERENCES

[1] Centers for Disease Control and Prevention. HIV Among Gay and Bisexual Men. September 2017. https://www.cdc.gov/hiv/pdf/group/msm/cdc-hiv-msm.pdf.

[2] Centers for Disease Control and Prevention. Estimated HIV incidence and prevalence in the United States, 2010–2015. *HIV Surveillance Supplemental Report* 2018;23(No. 1). Published March 2018. Accessed July 11, 2018.

[3] Centers for Disease Control and Prevention. HIV and African Americans. January 2018. https://www.cdc.gov/hiv/pdf/group/racialethnic/africanamericans/cdc-hiv-africanamericans.pdf.

[4] Prejean J, Song R, Hernandez A, Ziebell R, Green T, Walker F, Lin LS, An Q, Mermin J, Hall HI. Estimated HIV Incidence in the United States, 2006-2009. PLoS ONE. 2011;6(8): e17502.

[5] Centers for Disease Control and Prevention. HIV and Young Men Who Have Sex with Men. July 2014. https://www.cdc.gov/healthyyouth/sexualbehaviors/pdf/hiv_factsheet_ymsm.pdf.

[6] Centers for Disease Control and Prevention. HIV and African American Gay and Bisexual Men. January 2018. https://www.cdc.gov/hiv/pdf/group/msm/cdc-hiv-bmsm.pdf.

[7] Centers for Disease Control and Prevention. Diagnoses of HIV infection among adolescents and young adults in the United States and 6 dependent areas, 2011–2016. *HIV Surveillance Supplemental Report* 2018;23(No. 3). http://www.cdc.gov/hiv/library/reports/hiv-surveillance.html. Published May 2018. Accessed July 11, 2018.

[8] Millett GA, Flores SA, Peterson JL, Bakeman R. Explaining disparities in HIV infection among black and white men who have sex with men: a meta-analysis of HIV risk behaviors. AIDS. 2007;21:2083-2091.

[9] Lightfoot MA, Milburn NG. HIV prevention and African American youth: examination of individual-level behaviour is not the only answer. Culture, Health & Sexuality. 2009;11(7):731-742.

[10] Millett GA, Peterson JL, Wolitski RJ, Stall R. Greater Risk for HIV Infection of Black Men Who Have Sex With Men: A Critical Literature Review. AJPH. 2006;96:1007-1019.

[11] Millett GA, Peterson JL, Flores SA, et al. Comparisons of disparities and risks of HIV infection in black and other men who have sex with men in Canada, UK, and USA: a meta-analysis. Lancet. 2012;380:341-348.

[12] Crosby R, Holtgrave DR, Stall R, Peterson JL, Shouse L. Differences in HIV Risk Behaviors Among Black and White Men Who Have Sex With Men. STD. 2007;34(10):744-748.

[13] Bingham TA, Harawa NT, Johnson DF, Secura GM, MacKellar DA, Valleroy LA. The effect of partner characteristics on HIV infection among African men who have sex with men in the Young Men's Survey, Los Angeles, 1999-2000. AIDS Educ Prev. 2003;15(1 Suppl A):39-52.

[14] Harawa NT, Greenland S, Bingham TA, Johnson DF, Cochran SD, Cunningham WE, Celentano DD, Koblin BA, LaLota M, MacKellar DA, McFarland W, Shehan D, Stoyanoff S, Thiede H, Torian L, Valleroy LA. Associations of Race/Ethnicity With HIV Prevalence and HIV-Related Behaviors Among Young Men Who Have Sex With Men in 7 Urban Centers in the United States. J Acquir Immune Defic Syndr. 2004;35:526-536.

[15] Oster AM, Wiegand RE, Sionean C, Miles IJ, Thomas PE, Melendez-Morales L, Le BC, Millett GA. Understanding disparities in HIV infection between black and white MSM in the United States. AIDS. 2011;25:1103-1112.

[16] Sullivan PS, Peterson J, Rosenberg ES, Kelley CF, Cooper H, Vaughan A, Salazar LF, Frew P, Wingood G, DiClemente R, del Rio C, Mulligan M, Sanchez TH. Understanding Racial HIV/STI

Disparities in Black and White Men Who Have Sex with Men: A Multilevel Approach. PLoS ONE. 2013;9(3):e90514.

[17] Goodreau SM, Rosenberg ES, Jenness SM, Luisi N, Stansfield SE, Millett GA, et al. Sources of racial disparities in HIV prevalence in men who have sex with men in Atlanta, GA, USA: a modelling study. Lancet HIV. 2017;4(7):e311-e320.

[18] Rosenberg ES, Rothenberg RB, Kleinbaum DG, Stephenson RB, Sullivan PS. The implications of respondent concurrency on sex partner risk in a national, web-based study of men who have sex with men in the United States. JAIDS. 2013;63(4):514-521.

[19] Jannsen RS, Holtgrave DR, Valdiserri RO, Sheperd M, ABJ, Gayle HD, De Cock KM. The Serostatus Approach to Fighting the HIV Epidemic: Prevention Strategies for Infected Individuals. AJPH. 2001;91(7):1019-1024.

[20] Crepaz N, Lyles CM, Wolitski RJ, Passin WF, Rama SM, Herbst JH, Purcell DW, Malow RM, Stall R. Do prevention interventions reduce HIV risk behaviours among people living with HIV? A meta-analytic review of controlled trials. AIDS. 2006;20:143-157.

[21] Prado G, Lightfoot M, Brown CH. Macro-Level Approaches to HIV Prevention among Ethnic Minority Youth. Am Psychol. 2013;68(4):286-299.

[22] Centers for Disease Control and Prevention. Compendium of Evidence-Based Interventions and Best Practices for HIV Prevention. https://www.cdc.gov/hiv/research/interventionresearch/compendium/index.html. Accessed on July 11, 2018.

[23] Centers for Disease Control and Prevention. Compendium of Evidence-Based Interventions and Best Practices for HIV Prevention. Risk Reduction Chapter – Background. https://www.cdc.gov/hiv/pdf/research/interventionresearch/compendium/RR_Background.pdf.

[24] Herbst JH, Sherba RT, Crepaz N, DeLuca JB, Zohrabyan L, Stall RD, Lyles CM. A Meta-Analytic Review of HIV Behavioral Interventions for Reducing Sexual Risk Behaviors of Men Who Have Sex With Men. JAIDS. 2005;39:228-241.

[25] Herbst JH, Beeker C, Mathew A, McNally T, Passin WF, Kay LS, Crepaz N, Lyles CM, Briss P, Chattopadhyay S, Johnson RL. The Effectiveness of Individual-, Group-, and Community-Level HIV Behavioral Risk-Reduction Interventions for Adult Men Who Have Sex With Men. Am J Prev Med. 2007;32(4S):S38-S67.

[26] Johnson WD, Diaz RM, Flanders WD, Goodman M, Hill AN, Holtgrave D, Malow R, McClellan WM. Behavioral interventions to reduce risk for sexual transmission of HIV among men who have sex with men. Cochrane Database of Systematic Reviews. 2008, Issue 3.

[27] Mullen PD, Ramirez G, Strouse D, Hedges LV, Sogolow E. Meta-analysis of the Effects of Behavioral HIV Preventions on the Sexual Risk Behavior of Sexually Experienced Adolescents in Controlled Studies in the United States. JAIDS. 2002;30:S94-S105.

[28] Semaan S, Des Jarlais DC, Sogolow E, Johnson WD, Hedges LV, Ramirez G, Flores SA, Norman L, Sweat MD, Needle R. A Meta-analysis of the Effect of HIV Prevention Interventions on the Sex Behaviors of Drug Users in the United States. JAIDS. 2002;30:S73-S93.

[29] Lorimer K, Kidd L, Lawrence M, McPherson K, Cayless S, Cornish F. Systematic review of reviews of behavioural HIV prevention interventions among men who have sex with men. AIDS Care. 2013;25(2):133-150.

[30] Wohlfeiler D, Ellen JM. (2007). Chapter Fifteen: The Limits of Behavioral Interventions for HIV Prevention. In L. Cohen, V. Chavez, S. Chehimi (Eds.), *Prevention is Primary – Strategies for Community Well-Being* (pg. 329-347). San Francisco, CA, Jossey-Bass.

[31] Koblin B, Chesney M, Coates T. Effects of a behavioural intervention to reduce acquisition of HIV infection among men who have sex with men: the EXPLORE randomised controlled study. Lancet. 2004;364(9428):41–50.

[32] Latka MH, Hagan H, Kapadia F, Golub ET, Bonner S, Campbell JV, et al. A Randomized Intervention Trial to Reduce the Lending of Used Injection Equipment Among Injection Drug Users Infected With Hepatitis C. AJPH. 2008;98(5):853-861.

[33] Kamb ML, Fishbein M, Douglas Jr. JM, et al. Efficacy of Risk-Reduction Counseling to Prevent Human Immunodeficiency Virus and Sexually Transmitted Diseases. A Randomized Controlled Trial. JAMA. 1998;280(13):1161-1167.

[34] Kalichman SC, Zohren L, Eaton LA. Setting the Bar High or Setting Up to Fail? Interpretations and Implications of the EXPLORE Study (HPTN 015). AIDS Behav. 2014;29:625-633.

[35] Kurth AE, Celum C, Baeten JM, Vermund SH, Wasserheit JN. Combination HIV Prevention: Significance, Challenges, and Opportunities. Curr HIV/AIDS Rep. 2011;8(1):62-72.

[36] Celum C, Baeten JM, Hughes JP, Barnabas R, Liu A, Rooyen HV, et al. Integrated Strategies for Combination HIV Prevention: Principles and examples for men who have sex with men in the Americas and heterosexual African populations. JAIDS. 2013;63:S213-S220.

[37] UNAIDS. Combination HIV Prevention: Tailoring and Coordinating Biomedical, Behavioral, and Structural Strategies to Reduce New HIV Infections. Published October 2010. http://www.unaids.org/sites/default/files/media_asset/JC2007_Combination_Prevention_paper_en_0.pdf.

[38] Sullivan PS, Carballo-Dieguez A, Coates T, Goodreau SM, McGowan I, Sanders EJ, et al. Successes and challenges of HIV prevention in men who have sex with men. Lancet. 2012;380:388-399.

[39] Coates TJ, Richter L, Caceres C. Behavioural strategies to reduce HIV transmission: how to make them work better. Lancet. 2008;372:669-684.

[40] Karim QA, Karim SSA, Frohlich JA, Grobler AC, Baxter C, Mansoor LE, et al. Effectiveness and Safety of Tenofovir Gel, an Antiretroviral Microbicide for the Prevention of HIV Infection in Women. Science. 2010;329:1168-1174.

[41] Grant RM, Lama JR, Anderson PL, McMahan V, Liu AY, Vargas L, et al. Preexposure Chemoprophylaxis for HIV Prevention in Men Who Have Sex with Men. NEJM. 2010;363(27):2587-2599.

[42] Roland ME, Neilands TB, Krone MR, Katz MH, Franses K, Grant RM, et al. Seroconversion Following Nonoccupational Postexposure Prophylaxis against HIV. Clinical Infectious Diseases. 2005;41:1507-1513.

[43] Gray RH, Kigozi G, Kong X, Ssempiija V, Makumbi F, Wattya S, et al. The effectiveness of male circumcision for HIV prevention and effects on risk behaviors in a post-trial follow up study in Rakai, Uganda. AIDS. 2012;26(5):609-615.

[44] Rodger AJ, Cambiano V, Bruun T, Vernazza P, Collins S, van Lunzen J, et al. Sexual Activity Without Condoms and Risk of HIV Transmission in Serodifferent Couples When the HIV-Positive Partner Is Using Suppressive Antiretroviral Therapy. JAMA. 2016;316(2):171-181.

[45] Adimora AA, Auerbach JD. Structural Interventions for HIV Prevention in the United States. JAIDS. 2010;55:S132-S135.

[46] Gupta GR, Parkhurst JO, Ogden JA, Aggleton P, Mahal A. Structural approaches to HIV prevention. Lancet. 2008;372:764-775.

[47] Hanenberg RS, Rojanapithayakorn W, Kunasol P, Sokal DC. Impact of Thailand's HIV-control programme as indicated by the decline of sexually transmitted diseases. Lancet. 1994;344:243-245.

[48] Jana S, Basu I, Rotheram-Borus MJ, Newman PA. The Sonagachi Project: A Sustainable Community Intervention Program. AIDS Education and Prevention. 2004;16(5):405-414.

[49] Basu I, Jana S, Rotheram-Borus MJ, Swendeman D, Lee SJ, Newman P, Weiss R. HIV Prevention Among Sex Workers in India. JAIDS. 2004;36(3):845-852.

[50] Blankenship KM, Friedman SR, Dworkin S. Structural Interventions: Concepts, Challenges and Opportunities for Research. Journal of Urban Health. 2006;83(1):59-72.

[51] Craig P, Cooper C, Gunnell D, Haw S, Lawson K, Macintyre S, et al. Using natural experiments to evaluate population health interventions: new MRC guidance. J Epidemiol Community Health. 2012;66(12):1182-1186.

[52] Centers for Disease Control and Prevention. Compendium of Evidence-Based Interventions and Best Practices for HIV Prevention. Structural Interventions (SI) Chapter. https://www.cdc.gov/hiv/research/interventionresearch/compendium/si/complete-list.html. Updated on May 30, 2018. Accessed on July 11, 2018.

[53] Kirby D. Changes in sexual behaviour leading to the decline in the prevalence of HIV in Uganda: confirmation from multiple sources of evidence. Sex Transm Infect. 2008;84:ii35-ii41.

[54] USAID. What Happened in Uganda? Declining HIV Prevalence, Behaviour Change, and the National Response – Lessons Learned. September 2002. The Synergy Project. Washington, DC.

[55] Balkus JE, Brown E, Palanee T, Nair G, Gafoor Z, Zhang J, et al. An Empiric HIV Risk

Scoring Tool to Predict HIV-1 Acquisition in African Women. JAIDS. 2016;72(3):333-343.

[56] Smith DK, Pals SL, Herbst JH, Shinde S, Carey JW. Development of a Clinical Screening Index Predictive of Incidence HIV Infection Among Men Who Have Sex With Men in the United States. JAIDS. 2012;60(4):421-427.

[57] Hoenigl M, Weibel N, Mehta SR, Anderson CM, Jenks J, Green N, et al. Development and Validation of the San Diego Early Test Score to Predict Acute and Early HIV Infection Risk in Men Who Have Sex With Men. Clinical Infectious Diseases. 2015;61(3):468-475.

[58] Menza TW, Hughes JP, Celum CL, Golden MR. Prediction of HIV Acquisition Among Men Who Have Sex with Men. Sexually Transmitted Diseases. 2009;36(9):547-555.

[59] Kahle EM, Hughes JP, Lingappa JR, John-Stewart G, Celum C, Nakku-Joloba E, et al. An empiric risk scoring tool for identifying high-risk heterosexual HIV-1 serodiscordant couples for targeted HIV-1 prevention. JAIDS. 2013;62(3):339-347.

[60] Haukoos JS, Lyons MS, Lindsell CJ, Hopkins E, Bender B, Hsieh YH, et al. Derivation and Validation of the Denver Human Immunodeficiency Virus (HIV) Risk Score for Targeted HIV Screening. American Journal of Epidemiology. 2012;175(8):838-846.

[61] Jones J, Hoenigl M, Siegler A, Sullivan P, Little S, Rosenberg E. Assessing the Performance of Three HIV Incidence Risk Scores in a Cohort of Black and White MSM in the South. Sexually Transmitted Diseases. 2017;44(5):297-302.

[62] Lima VD, Hogg RS, Harrigan PR, Moore D, Yip B, Wood E, et al. Continued improvement in survival among HIV-infected individuals with newer forms of highly active antiretroviral therapy. AIDS. 2007;21:685-692.

[63] Marcus JL, Chao CR, Leyden WA, Xu L, Quessenberry CP, Klein DB, et al. Narrowing the Gap in Life Expectancy Between HIV-Infected and HIV-Uninfected Individuals with Access to Care. JAIDS. 2016; 73(1):39-46.

[64] Dilley JW, Woods WJ, McFarland WM. Are Advances in Treatment Changing Views about High-Risk Sex? NEJM. 1997;337(7):501-502.

[65] Cox J, Beauchemin J, Allard R. HIV status of sexual partners is more important than antiretroviral treatment related perceptions for risk taking by HIV positive MSM in Montreal, Canada. Sex Transm Infect. 2004;80:518-523.

[66] Katz MH, Schwarcz SK, Kellogg TA, Klausner JD, Dilley JW, Gibson S, McFarland W. Impact of Highly Active Antiretroviral Treatment on HIV Seroincidence Among Men Who Have Sex With Men: San Francisco. Am J Public Health. 92:388-394.

[67] van Kesteren NMC, Hospers HJ, Kok G. Sexual risk behavior among HIV-positive men who have sex with men: A literature review. Patient Education and Counseling. 2007;65:5-20.

[68] Chen SY, Gibson S, Weide D, McFarland W. Unprotected Anal Intercourse Between Potentially HIV-Serodiscordant Men Who Have Sex With Men, San Francisco. JAIDS. 2003;33(2):166-170.

[69] Chen SY, Gibson S, Katz MH, Klausner JD, Dilley JW, Schwarcz SK, Kellogg TA, McFarland W. Continuing Increases in Sexual Risk Behaviors and Sexually Transmitted Diseases among Men Who Have Sex With Men: San Francisco, Calif, 1999-2001. Am J Public Health. 92(9):1387-1388.

[70] Dukers NHTM, Goudsmit J, de Wit JBF, Prins M, Weverling GJ, Coutinho RA. Sexual risk behaviour relates to the virological and immunological improvements during highly active antiretroviral therapy in HIV-1 infection. AIDS. 2001;15:369-378.

[71] Elford J, Bolding G, Sherr L. High-risk sexual behaviour increases among London gay men between 1998 and 2001: what is the role of HIV optimism. AIDS. 2002;16:1537-1544.

[72] Centers for Disease Control and Prevention. Increases in unsafe sex and rectal gonorrhea among men who have sex with men—San Francisco, California, 1994–1997. MMWR Morb Mortal Wkly Rep. 1999;48:45–48.

[73] Scheer S, Chu PL, Klausner JD, Katz MH, Schwarcz SK. Effect of highly active antiretroviral therapy on diagnoses of sexually transmitted diseases in people with AIDS. Lancet. 2001; 357:432–435.

[74] Stolte IG, de Wit JBF, van Eeden A, Coutinho RA, Dukers NHTM. Perceived viral load, but not actual HIV-1 RNA load, is associated with sexual risk behaviour among HIV-infected homosexual men. AIDS. 2004;18:1943-1949.

[75] Stolte IG, Coutinho RA. Risk behaviour and sexually transmitted diseases are on the rise in gay men, but what is happening with HIV? Current Opinion in Infectious Diseases. 2002;15:37-41.

[76] MacKellar DA, Valleroy LA, Secure GM, Behel S, Bingham T, Celentano DD, et al. Perceptions of Lifetime Risk and Actual Risk for Acquiring HIV Among Young Men Who Have Sex with Men. AIDS Behavior. 2007;11:263-270.

[77] Maughan-Brown B, Venkataramani AS. Accuracy and determinants of perceived HIV risk among young women in South Africa. BMC Public Health. 2018;18:42.

[78] Remien RH, Halkitis PN, O'Leary A, Wolitski RJ, Gomez CA. Risk Perception and Sexual Risk Behaviors Among HIV-Positive Men on Antiretroviral Therapy. AIDS and Behavior. 2005;9(2):167-176.

[79] Reisen CA, Poppen PJ. Partner-Specific Risk Perception: A New Conceptualization of Perceived Vulnerability to STDs. Journal of Applied Social Psychology. 1999;29(4):667-684.

[80] Napper LE, Reynolds GL, Fisher DG. Measuring perceived susceptibility, perceived vulnerability, and perceived risk of HIV infection. In: Lavino JG, Neumann RB, editors. Psychology of risk perception. Hauppauge: Nova Science Publishers, Inc.; 2010.

[81] Simoni JM, Pantalone DW. Secrets and Safety in the age of AIDS: does HIV disclosure lead to safer sex? Top HIV Med. 2004;12(4):109-118

[82] Torrone EA, Thomas JC, Maman S, Pettifor AE, Kaufman JS, Sena AC, et al. Risk Behavior Disclosure During HIV Test Counseling. AIDS Patient Care and STDs. 2010;24(9):551-561.

[83] Centers for Disease Control and Prevention. Revised Recommendations for HIV Testing of Adults, Adolescents, and Pregnant Women in Health-Care Settings. MMWR Morb Mortal Wkly Rep. 2006;55(RR14):1-17.

[84] Goldstein ND, Welles SL, Burstyn I. To Be or Not to Be. Bayesian Correction for Misclassification of Self-reported Sexual Behaviors Among Men Who Have Sex with Men. Epidemiology. 2015;26:637-644.

[85] Rao A, Tobin K, Davey-Rothwell M, Latkin CA. Social Desirability Bias and Prevalence of Sexual HIV Risk Behaviors Among People Who Use Drugs in Baltimore, Maryland: Implications for Identifying Individuals Prone to Underreporting Sexual Risk Behaviors. AIDS Behavior. 2017;21:2207-2214.

[86] Centers for Disease Control and Prevention. Advancing HIV Prevention: New Strategies for a Changing Epidemic -- United States, 2003. MMWR Morb Mortal Wkly Rep. 2003;52(15):329-332.

[87] Connor EM, Sperling RS, Gelber R, Kiselev P, Scott G, O'Sullivan MJ, VanDyke R, Bey M, Shearer W, Jacobson RL, Jimenez E, O'Neill E, Bazin B, Delfraissy JF, Culnane M, Coombs R, Elkins M, Moye J, Stratton P, Balsley J. Reduction of Maternal-Infant Transmission of Human Immunodeficiency Virus Type 1 with Zidovudine Treatment. NEJM. 1994;331(18):1173-1180.

[88] Cohen MS, Chen YQ, McCauley M, et al. Prevention of HIV-1 Infection with Early Antiretroviral Therapy. NEJM. 2011;365(6):493-505.

[89] Wilson DP, Law MG, Grulich AE, Cooper DA, Kaldor JM. Relation between HIV viral load and infectiousness: a model-based analysis. Lancet. 2008;372:314-320.

[90] Quinn TC, Wawer MJ, Sewankambo N, Serwadda D, Li C, Wabwire-Mangen F, Meehan MO, Lutalo T, Gray RH. Viral Load and Heterosexual Transmission of Human Immunodeficiency Virus Type 1. NEJM. 2000;342:921-929.

[91] Attia S, Egger M, Muller M, Zwahlen M, Low N. Sexual transmission of HIV according to viral load and antiretroviral therapy: systematic review and meta-analysis. AIDS. 2009;23:1397-1404.

[92] Das M, Chu PL, Santos GM, Scheer S, Vittinghoff E, McFarland W, Colfax GN. Decreases in Community Viral Load Are Accompanied by Reductions in New HIV Infections in San Francisco. PLoS ONE. 2010;5(6):e11068.

[93] Montaner JS, Lima VD, Barrios R, Yip B, Wood E, Kerr T, Shannon K, Harrigan PR, Hogg RS, Daly P, Kendall P. Association of highly active antiretroviral therapy coverage, population viral load, and yearly new HIV diagnoses in British Columbia, Canada: a population-based study. Lancet. 2010;376:532-539.

[94] Granich RM, Gilks CF, Dye C, De Cock KM, Williams BG. Universal voluntary HIV testing with immediate antiretroviral therapy as a strategy for elimination of HIV transmission: a mathematical model. Lancet. 2009;373:48-57.

[95] Cori A, Ayles H, Beyers N, Schaap A, Floyd S, Sabapathy K, Eaton JW, Hauck K, Smith P, Griffith S, Moore A, Donnell D, Vermund SH, Fidler S, Hayes R, Fraser C. HPTN 071 (PopART): A Cluster-Randomized Trial of the Population Impact of an HIV Combination Prevention Intervention Including Universal Testing and Treatment: Mathematical Model. PLoS ONE. 2014;9(1):e84511.

[96] Office of National AIDS Policy. National HIV/AIDS Strategy for the United States. Washington, DC: Office of National AIDS Policy; 2010.

[97] Office of National AIDS Policy. National HIV/AIDS Strategy – Improving Outcomes: Accelerating Progress Along The HIV Care Continuum. Washington, DC: Office of National AIDs Policy; 2013.

[98] U.S. Department of Health and Human Services. AIDS.gov - HIV/AIDS Care Continuum http://aids.gov/federal-resources/policies/care-continuum/. Published December 2013. Accessed June 5, 2014.

[99] Mugavero MJ, Amico KR, Horn T, Thompson MA. The State of Engagement in HIV Care in the United States: From Cascade to Continuum to Control. Clinical Infectious Diseases. 2013;57(8):1164-1171.

[100] AIDS.gov. HIV/AIDS Care Continuum. https://www.aids.gov/federal-resources/policies/care-continuum/. Accessed June 5, 2014.

[101] Cheever LW. Engaging HIV-Infected Patients in Care: Their Lives Depend on It. Clinical Infectious Disease. 2007;44:1500-1502.

[102] Milloy MJ, Kerr T, Buxton J, Rhodes T, Krusi A, Guillemi S, Hogg R, Montaner J, Wood E. Social and Environmental Predictors of Plasma HIV RNA Rebound Among Injection Drug Users Treated With Antiretroviral Therapy. JAIDS. 2012;59:393-399.

[103] Westergaard RP, Kirk GD, Richesson DR, Galai N, Mehta SH. Incarceration Predicts Virologic Failure for HIV-Infected Injection Drug Users Receiving Antiretroviral Therapy. CID. 2011;53(7):725-731.

[104] Centers for Disease Control and Prevention. Monitoring selected national HIV prevention and care objectives by using HIV surveillance data – United States and 6 dependent areas - 2011. HIV Surveillance Supplemental Report 2013;18(No. 5). http://www.cdc.gov/hiv/topics/surveillance/resources/reports/surveillance/. Published October 2013. Accessed June 3, 2014.

[105] Centers for Disease Control and Prevention. National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention. Selected National HIV Prevention and Care Outcomes. https://www.cdc.gov/hiv/pdf/library/slidesets/cdc-hiv-prevention-and-care-outcomes.pdf Accessed June 5, 2018.

[106] Rosenberg ES, Millett GA, Sullivan PS, del Rio C, Curran JW. Understanding the HIV disparities between black and white men who have sex with men in the USA using the HIV care continuum: a modeling study. Lancet HIV. 2014;1(3):e112-e118.

[107] Centers for Disease Control and Prevention. Prevalence and Awareness of HIV Infection Among Men Who Have Sex With Men – 21 Cities, United States, 2008. MMWR 2010;59:1201-1207.

[108] Wejnert C, Le B, Rose CE, Oster AM, Smith AJ, Zhu J, Paz-Bailey G. HIV Infection and Awareness among Men Who Have Sex With Men-20 Cities, United States, 2008 and 2011. PLoS ONE. 2013;8(10):e76878.

[109] Singh S, Song R, Johnson AS, McCray E, Hall HI. HIV Incidence, Prevalence, and Undiagnosed Infections in U.S. Men Who Have Sex With Men. Ann Intern Med. 2018;168:685-694.

[110] Beer L, Oster AM, Mattson CL, Skarbinski J. Disparities in HIV transmission risk among HIV-infected black and white men who have sex with men, United States, 2009. AIDS. 2014;28:105-114.

[111] Whiteside YO, Cohen SM, Bradley H, Skarbinski J, Hall HI. Progress Along the Continuum of HIV Care Among Black with Diagnosed HIV – United States, 2010. MMWR. 2014;63(5):85-89.

[112] Editorial. U=U taking off in 2017. Lancet HIV. 2017;4(11):e475.

[113] Bavinton BR, Pinto AN, Phanuphak N, Grinsztejn B, Prestage GP, Zablotska-Manos IB, et al. Viral suppression and HIV transmission in serodiscordant male couples: an international, prospective, observational, cohort study. Lancet HIV. 2018;5:e438-e447.

[114] Davila JA, Miertschin N, Sansgiry S, Schwarzwald H, Henley C, Giordano TP. Centralization of HIV services in HIV-Positive African-American and Hispanic youth improves retention in care. AIDS Care. 2013;202-206.

[115] Hightow-Weidman LB, Smith JC, Valera E, Matthews DD, Lyons P. Keeping Them in "Style": Finding, Linking, and Retaining Young HIV-Positive Black and Latino Men Who Have Sex with Men in Care. AIDS Patient Care and STDs. 2011;25(1):37-45.

[116] Centers for Disease Control and Prevention. Compendium of Evidence-Based Interventions and Best Practices for HIV Prevention. Medication Adherence (MA) Chapter. https://www.cdc.gov/hiv/research/interventionresearch/compendium/ma/complete.html. Updated on September 22, 2017. Accessed on July 11, 2018.

[117] Bouris A, Jaffe K, Eavou R, Liao C, Kuhns L, Voisin D, et al. Project nGage: Results of a Randomized Controlled Trial of a Dyadic Network Support Intervention to Retain Young Black Men Who Have Sex With Men in HIV Care. AIDS Behavior. 2017;21:3618-3629.

[118] Hussen SA, Harper GW, Bauermesiter JA, Hightow-Weidman LB. Psychosocial Influences on Engagement in Care Among HIV-Positive Young Black Gay/Bisexual and Other Men Who Have Sex with Men. AIDS Patient Care and STDs. 2015;29(2):77-85.

[119] Hightow-Weidman L, LeGrand D, Choi SK, Egger J, Hurt CB, Muessig KE. Exploring the HIV continuum of care among young black MSM. PLoS ONE. 2017;12(6):e0179688.

[120] Magnus M, Jones K, Phillips G, Binson D, Hightow-Weidman L, Richards-Clarke C, et al. Characteristics Associated With Retention Among African American and Latino Adolescent HIV-Positive Men: Results From the Outreach, Care, and Prevention to Engage HIV-Seropositive Young MSM of Color Special Project of National Significance Initiative. JAIDS. 2010;53(4):529-536.

[121] Wilson PA, Kahana SY, Fernandez MI, Harper GW, Mayer K, Wilson CM, et al. Sexual Risk Behavior Among Virologically Detectable Human Immunodeficiency Virus-Infected Young Men Who Have Sex With Men. JAMA Pediatrics. 2016;170(2):125-131.

[122] Kelly JA, Hoffman RG, Rompa D, Gray M. Protease inhibitor combination therapies and perceptions of gay men regarding AIDS severity and the need to maintain safer sex. AIDS. 1998;12:F91-F95.

[123] van der Straten A, Gomez CA, Saul J, Quan J, Padian N. Sexual risk behaviors among heterosexual HIV serodiscordant couples in the era of post-exposure prevention and viral suppressive therapy. AIDS. 2000;14(4):F47-F54.

[124] Becker MH. The health belief model and personal health behavior. Health Educ Monogr. 1974;2:324–473.

[125] Bandura, A. (1994). Social cognitive theory and exercise of control over HIV infection. In R. J. DiClemente, editor; & J. L. Peterson, editor. (Eds.), *Preventing AIDS: Theories and methods of behavioral interventions* (pp. 25-59). New York: Plenum Press**.**

[126] Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention, and behavior: An introduction to theory and research*. Reading, MA: Addison-Wesley.

[127] Ajzen I. The theory of planned behavior. Organ Behav Hum Decis Process. 1991;50:179–211.

[128] Rogers RW. A protection motivation theory of fear appeals and attitude change. J Psychol. 1975;91(1):93–114.

[129] Witte K. Putting the fear back into fear appeals: the extended parallel process model. Commun Monogr. 1992;59:329–49.

[130] Catania JA, Kegeles SM, Coates TJ. Towards an understanding of risk behavior: an AIDS risk reduction model (ARRM). Health Educ Q. 1990;17(1):53–72.

[131] Napper LE, Fisher DG, Reynolds GL. Development of the Perceived Risk of HIV Scale. AIDS Behavior. 2012;16:1075-1083.

[132] Tsui H, Lau JTF, Xiang W, Gu J, Wang Z. Should Associations between HIV-Related Risk Perceptions and Behaviors or Intentions Be Positive or Negative. PLoS ONE. 2012;7(12):e52124.

[133] Kesler MA, Kaul R, Liu J, Loutfy M, Gesink D, et al. Actual sex risk and perceived risk of HIV acquisition among HIV-negative men who have sex with men in Toronto, Canada. BMC Public Health. 2016;16:254.

[134] Gerrard M, Gibbons FX, Bushman BJ. Relation Between Perceived Vulnerability to HIV and Precautionary Sexual Behavior. Psychological Bulletin. 1996;119(3):390-409.

[135] Kalichman SC, Eaton L, Cain D, et al. Changes in HIV Treatment Beliefs and Sexual Risk Behaviors Among Gay and Bisexual Men, 1997-2005. Health Psychology. 2007;26(5):650-656.

[136] Kalichman SA, Rompa D, Cage M, Austin J, Luke W, Barnett T, Tharnish P, Mowrey J, Schinazi RF. Sexual transmission risk perceptions and behavioural correlates of HIV concentrations in semen. AIDS Care. 2002;14(3):343-349.

[137] Peterson JL, Miner MH, Brennan DJ, Simon Rosser BR. HIV Treatment Optimism and Sexual Risk Behaviors among HIV Positive African American Men who have Sex with Men. AIDS Educ Prev. 2012;24(2):91-101.

[138] Holtzman D, Bland SD, Lansky A, Mack KA. HIV-Related Behaviors and Perceptions Among Adults in 25 States: 1997 Behavioral Risk Factor Surveillance System. American Journal of Public Health. 2001;91(11):1882-1888.

[139] Belcher L, Sternberg MR, Wolitski RJ, Halkitis P, Hoff C. Condom Use and Perceived Risk of HIV Transmission among Sexually Active HIV-Positive Men who have Sex with Men. AIDS Educ Prev. 2005;17(1):79-89.

[140] Ostrow DE, Fox KJ, Chmiel JS, Silvestre A, Visscher BR, Vanable PA, Jacobson LP, Strathdee SA. Attitudes towards highly active antiretroviral therapy are associated with sexual risk taking among HIV-infected and uninfected homosexual men. AIDS. 2002;16:775-780.

[141] Crepaz N, Hart TA, Marks G. Highly Active Antiretroviral Therapy and Sexual Risk Behavior. JAMA. 2004;292(2):224-236.

[142] Vanable PA, Ostrow DG, McKirnan DJ. Viral load and HIV treatment attitudes as correlates of sexual risk behavior among HIV-positive gay men. Journal of Psychosomatic Research. 2003;53:263-269.

[143] Begley K, Chan DJ, Jeganathan S, Batterham M, Smith DE. Factors associated with unprotected anal intercourse between HIV-positive men and regular male partners in a Sydney cohort. International Journal of STD and AIDS. 2009;20:704-707.

[144] Khumasen N, Stephenson R. Beliefs and Perception about HIV/AIDS, Self-Efficacy, and HIV Sexual Risk Behaviors among Young Thai Men who have Sex with Men. AIDS Educ Prev. 2017;29(2):175-190.

[145] Baume CA. The relationship of perceived risk to condom use: Why results are inconsistent. Social Marketing Quarterly. 2000;6(1):33-43.

[146] Kowaleski MR, Henson KD, Longshore D. Rethinking Perceived HIV Risk and Health Behavior: A Critical Review of HIV Prevention Research. Health Education & Behavior. 1997;24(3):313-325.

[147] Mehrotra P, Noar SM, Zimmerman ZS, Palmgreen P. Demographic and Personality Factors as Predictors of HIV/STD Partner-Specific Risk Perceptions: Implications for Interventions. AIDS Educ Prev. 2009;21(1):39-54.

[148] Suarez TP, Kelly JA, Pinkerton SD, Stevenson YL, Hayat M, Smith MD, et al. Influence of a Partner's HIV Serostatus, Use of Highly Active Antiretroviral Therapy, and Viral Load on Perceptions of Sexual Risk Behavior in a Community Sample of Men Who Have Sex With Men. JAIDS. 2001;28:471-477.

[149] van der Velde FW, Hooykaas C, van der Plight J. Conditional versus Unconditional Risk Estimates in Models of AIDS-Related Risk Behavious. Psychology and Health. 1996;12:87-100.

[150] Chard AN, Metheny N, Stephenson R. Perceptions of HIV Seriousness, Risk, and Threat Among Online Samples of HIV-Negative Men Who Have Sex With Men in Seven Countries. JMIR Public Health and Surveillance. 2017;3(2):e37.

[151] Fan W, Yin L, Qian H, Li D, Shao Y, Vermund SH, et al. HIV Risk Perception among HIV Negative or Status-Unknown Men Who Have Sex With Men in China. BioMed Research International. 2014;232451.

[152] MacKellar DA, Valleroy LA, Secura GM, Behel S, Bingham T, Celentano DD, et al. Unrecognized HIV Infection, Risk Behaviors, and Perceptions of Risk Among Young Men Who Have Sex With Men. JAIDS. 2005;38(5):603-614.

[153] Stephenson R, White D, Darbes L, Hoff C, Sullivan P. HIV Testing Behaviors and Perceptions of Risk of HIV Infection Among MSM with Main Partners. AIDS Behavior. 2015;19:553-560.

[154] MacKellar DA, Gallagher KM, Finlayson T, et al. Surveillance of HIV risk and prevention behaviors of men who have sex with Understanding Black/White Disparities in HIV men - A national application of venue-based, time-space sampling. Public Health Reports. 2007;122: 39–47.

[155] Collins LM & Lanza ST. (2010). *Latent class and latent transition analysis: With applications in the social, behavioral, and health sciences*. Hoboken, NJ: John Wiley & Sons, Inc.

[156] Bray BC, Lanza ST, Tan X. Eliminating Bias in Classify-Analyze Approaches for Latent Class Analysis. Structural Equation Modeling. 2015;22(1):1-11.

[157] PROC LCA & PROC LTA (Version 1.3.2) [Software]. (2015). University Park: The Methodology Center, Penn State. Retrieved from http://methodology.psu.edu

[158] Dziak JJ, Coffman DL, Lanza ST, Li R. (2012). Sensitivity and specificity of information criteria. University Park: The Methodology Center, Penn State. Retrieved from http://methodology.psu.edu

[159] Nylund KL, Asparouhov T, Muthen BO. Deciding on the Number of Classes in Latent Class Analysis and Growth Mixture Modeling: A Monte Carlo Simulation Study. Structural Equation Modeling. 2007;14(4):535-569.

[160] Lanza ST, Collins LM, Lemmon DR, Schafer JL. PROC LCA: A SAS Procedure for Latent Class Analysis. Structural Equation Modeling. 2007;14(4):671-694.

[161] Carey MP, Schroder KEE. Development and Psychometric Evaluation of the Brief HIV Knowledge Questionnaire. AIDS Educ Prev. 2002;14(2):172-182.

[162] Fang J. Using SAS® Procedures FREQ, GENMOD, LOGISTIC, and PHREG to Estimate Adjusted Relative Risks – A Case Study. SAS Global Forum 2011, Paper 345-2011.

[163] Zou G. A Modified Poisson Regression Approach to Prospective Studies with Binary Data. American Journal of Epidemiology. 2004;159(7):702-706.

[164] Grov C, Rendina HJ, Patel VV, Kelvin E, Anastos K, Parsons JT. Prevalence of and Factors Associated with the Use of HIV Serosorting and Other Biomedical Prevention Strategies Among Men Who Have Sex with Men in a US Nationwide Survey. AIDS and Behavior. 2018; doi: 10.1007/s10461-018-2084-7. [Epub ahead of print]

[165] Siegler AJ, Sullivan PS, Khosropour CM, Rosenberg ES. The role of intent in serosorting behaviors among MSM sexual partnerships. JAIDS. 2013;64(3):1-17.

[166] Chen YH, Vallabhaneni S, Raymond HF, McFarland W. Predictors of Serosorting and Intention to Serosort Among Men Who Have Sex with Men, San Francisco. AIDS Education and Prevention. 2012;24(6):564-573.

[167] Van den Boom W, Konings R, Davidovich U, Sandfort T, Prins M, Stolte IG. Is serosorting effective in reducing the risk of HIV-infection among men who have sex with men with casual partners? JAIDS. 2014;65(3):375-379.

[168] Merlo J, Yang M, Chaix B, Lynch J, Rastam L. A brief conceptual tutorial on multilevel analysis in social epidemiology: investigating contextual phenomena in different groups of people. J Epidemiol Community Health. 2005;59:729-736.

[169] White D, Rosenberg ES, Cooper HLF, del Rio C, Sanchez TS, Salazar LF, et al. Racial Differences in the validity of self-reported drug use among men who have sex with men in Atlanta, GA. Drug Alcohol Depend. 2014;138:146-153.

[170] Centers for Disease Control and Prevention. HIV Testing and Risk Behaviors Among Gay, Bisexual, and Other Men Who Have Sex with Men – United States. MMWR Morb Mortal Wkly Rep. 2013;62(47):958-962.

[171] Kojima N, Davey DJ, Klausner JD. Pre-exposure prophylaxis for HIV infection and new sexually transmitted infections among men who have sex with men. AIDS. 2016;30:2251-2252.

[172] Centers for Disease Control and Prevention. HIV Infection Risk, Prevention, and Testing Behaviors among Men Who Have Sex With Men—National HIV Behavioral Surveillance, 20 U.S. Cities, 2014. HIV Surveillance Special Report 15. http://www.cdc.gov/hiv/library/reports/surveillance/#panel2. Published January 2016. Accessed 11/9/2017.

[173] Sullivan PS, Salazar L, Buchbinder S, Sanchez TH. Estimating the proportion of HIV transmissions from main sex partners among men who have sex with men in five US cities. AIDS. 2009;23:1153-1162.

[174] Williams M, Ross MW, Bowen AM, Timpson S, McCoy HV, Perkins K, et al. An investigation of condom use frequency by frequency of sex. Sexually Transmitted Infections. 2001;77:433-435.

[175] Hoff CC, Chakravarty D, Beougher SC, Neilands TB, Darbes LA. Relationship Characteristics Associated with Sexual Risk Behavior Among MSM in Committed Relationships. AIDS Patient Care and STDs. 2012;26(12):738-745.

[176] Stein MD, Freedberg KA, Sullivan LM, Savetsky J, Levenson SM, Hingson R, Samet JH. Sexual Ethics. Disclosure of HIV-Positive Status to Partners. Arch Intern Med. 1998;158:253-257.

[177] O'Brien ME, Richardson-Alston G, Ayoub M, Magnus M, Peterman TA, Kissinger P. Prevalence and Correlates of HIV Serostatus Disclosure. Sexually Transmitted Diseases. 2003;30(9):731-735.

[178] Pinkerton SD, Galletly CL. Reducing HIV Transmission Risk by Increasing Serostatus Disclosure: A Mathematical Modeling Analysis. AIDS Behav. 2007;11:698-705.

[179] O'Connell AA, Reed SJ, Serovich JA. The Efficacy of Serostatus Disclosure for HIV Transmission Risk Reduction. AIDS Behav. 2015;19(2):283-290.

[180] Mustanski B, Newcomb ME, Clerkin EM. Relationship Characteristics and Sexual Risk-Taking in Young Men Who Have Sex With Men. Health Psychology. 2011;30(5):597-605.

[181] Newcomb NE, Ryan DT, Garofalo R, Mustanski B. The Effects of Sexual Partnership and Relationship Characteristics on Three Sexual Risk Variables in Young Men Who Have Sex with Men. Arch Sex Behav. 2014;43:61-72.

[182] Liang KY, Zeger SL. Longitudinal data analysis using generalized linear models. Biometrica. 1986;73:13-22.

[183] SAS Institute Inc. 2008. *SAS/STAT®9.2 User's Guide*. Cary, NC: SAS Institute Inc.

[184] Gosho M. Criteria to Select a Working Correlation Structure for the Generalized Estimating Equation Methods in SAS. Journal of Statistical Software. 2014;57:1-10.

[185] Kleinbaum DG, Klein M (2010). *Logistic Regression. A Self-Learning Text. Third Edition.* New York, NY: Springer Science+Business Media LLC.

[186] VanderWeele TJ, Knol MJ. A Tutorial on Interaction. Epidemiologic Methods. 2014;3(1):33-72.

[187] Hosmer DW, Lemeshow S. Confidence Interval Estimation of Interaction. Epidemiology. 1992;3(5):452-456.

[188] Marcus U, Gassowski M, Drewes J. HIV risk perception and testing behaviours among men having sex with men (MSM) reporting potential transmission risks in the previous 12 months from a large online sample of MSM living in Germany. BMC Public Health. 2016;16:1111.

[189] Vargas SK, Konda KA, Leon SR, Brown B, Klausner JD, Lindan C, et al. The Relationship Between Risk Perception and Frequency of HIV Testing Among Men Who Have Sex with Men and Transgender Women, Lima, Peru. AIDS and Behavior. 2018;DOI:10.1007/s10461-017-2018-9.

[190] Bird JDP, Fingerhut DD, McKirnan DJ. Ethnic differences in HIV-disclosure and sexual risk. AIDS Care. 2011;23(4):444-448.

[191] Eaton LA, Kalichman SC, Cherry C. Sexual Partner Selection and HIV Risk Reduction Among Black and White Men Who Have Sex With Men. American Journal of Public Health. 2010;100(3):503-509.

[192] Grov C, Rendina HJ, Moody RL, Ventuneac A, Parsons JT. HIV Serosorting, Disclosure, and Strategic Positioning Among Highly Sexually Active Gay and Bisexual Men. AIDS Patient Care and STDs. 2015;29(10):559-568.

[193] Winter AK, Sullivan PS, Khosropour CM, Rosenberg ES. Discussion of HIV Status by Serostatus and Partnership Sexual Risk among Internet-Using MSM in the United States. JAIDS. 2012;60(5):525-529.

[194] Ciccarone DH, Kanouse DE, Collins RL, Miu A, Chen JL, Morton SC, et al. Sex Without Disclosure of Positive HIV Serostatus in a US Probability Sample of Persons Receiving Medical Care for HIV Infection. American Journal of Public Health. 2003;93(6):949-954.

[195] Sanchez TH, Kelley CF, Rosenberg E, Luisi N, O'Hara B, Lambert R, et al. Lack of Awareness of (HIV) Infection: Problems and Solutions with Self-reported HIV Serostatus of Men Who Have Sex with Men. Open Forum Infectious Diseases. 2014;1(2):ofu084.

[196] Hernandez-Romieu AC, Sullivan PS, Rothenberg R, Grey J, Luisi N, Sanchez T, et al. Concordance of Demographic Characteristics, Sexual Behaviors, and Relationship Attributes Among Sex Dyads of Black and White Men Who Have Sex with Men. Arch Sex Behav. 2016;45:1463-1470.

[197] De Cock KM. Plus ca change…Antiretroviral Therapy, HIV Prevention, and the HIV Treatment Cascade. CID. 2014;58(7):1012-1014.

[198] Kitahata MM, Gange SJ, Abraham AG et al. Effect of Early versus Deferred Antiretroviral Therapy for HIV on Survival. NEJM. 2009;360(18):1815-1826.

[199] Ray M, Logan R, Sterne JAC et al. The effect of combined antiretroviral therapy on the overall mortality of HIV-infected individuals. AIDS. 2010;24:123-137.

[200] Holtzman CW, Shea JA, Glanz K, Jacobs LM, Gross R, Hines J, et al. Mapping Patient-Identified Barriers and Facilitators to Retention in HIV Care and Antiretroviral Therapy Adherence to Andersen's Behavioral Model. AIDS Care. 2015;27(7):817-828.

[201] Arnold EA, Weeks J, Benjamin M, Steward WR, Pollack LM, Kegeles SM, et al. Identifying social and economic barriers to regular care and treatment for Black men who have sex with men and women (BMSMW) and who are living with HIV: a qualitative study from the Bruthas cohort. BMC Health Services Research. 2017;17:90.

[202] Bolsewicz K, Debattista J, Vallely A, Whittaker A, Fitzgerald L. Factors associated with antiretroviral uptake and adherence: a review. Perspectives from Australia, Canada, and the United Kingdom. AIDS Care. 2015;27(12):1429-1438.

[203] Li L, Lee SJ, Thammawijaya P, Jiraphongsa C, Rotheram-Borus MJ. Stigma, social support, and depression among people living with HIV in Thailand. AIDS Care. 2009;21(8):1007-1013.

[204] Garrido-Hernansaiz H, Alonso-Tapia J. Social Support in Newly Diagnosed People living With HIV: Expectations and Satisfaction Along Time, Predictors, and Mental Health Correlates. JANAC. 2017;28(6):849-861.

[205] Cornelius T, Jones M, Merly C, Welles B, Kalichman MO, Kalichman SC. Impact of food, housing, and transportation insecurity on ART adherence: a hierarchical resources approach. AIDS Care. 2017;29(4):449-457.

[206] Cunningham WE, Andersen RM, Katz MH, Stein MD, Turner BJ, Crystal S et al. The Impact of Competing Subsistence Needs and Barriers on Access to Medical Care for Persons with Human Immunodeficiency Virus Receiving Care in the United States. Medical Care. 1999;37(12):1270-1281.

[207] Reisner SL, Mimiaga MJ, Skeer M, Perkovich B, Johnson CV, Safren SA. A Review of HIV Antiretroviral Adherence and Intervention Studies Among HIV-Infected Youth. Top HIV Med. 2009;17(1):14-25.

[208] Fields EL, Bogart LA, Thurston IB, Hu CH, Skeer MR, Safren SA, et al. Qualitative Comparison of Barriers to Antiretroviral Medication Adherence Among Perinatally and Behaviorally HIV-Infected Youth. Qualitative Health Research. 2017;27(8):1177-1189.

[209] Rao D, Kekwaletswe TC, Hosek S, Martinez J, Rodriguez F. Stigma and social barriers to medication adherence with urban youth living with HIV. AIDS Care. 2007;19(1):28-33.

[210] Merzel C, VanDevanter N, Irvine M. Adherence to Antiretroviral Therapy among Older Children and Adolesents with HIV: A Qualitative Study on Psychosocial Contexts. AIDS Patient Care and STDs. 2008;22(12):977-987.

[211] Centers for Disease Control and Prevention. CDC Fact Sheet. HIV among Gay and Bisexual Men. February 2017. https://www.cdc.gov/nchhstp/newsroom/docs/factsheets/cdc-msm-508.pdf. Accessed on November 5, 2017.

[212] Arnold EA, Rebchook GM, Kegeles SM. "Triply Cursed": Racism, homophobia, and HIV-related stigma are barriers to regular HIV testing, treatment adherence, and disclosure among young Black gay men. Cult Health Sex. 2014;16(6):710-722.

[213] Hussen SA, Andes K, Gilliard D, Chakraborty R, del Rio C, Malebranche DJ. Transition to Adulthood and Antiretroviral Adherence Among HIV-Positive Young Black Men Who Have Sex With Men. American Journal of Public Health. 2015;105(4):725-731.

[214] Palinkas LA, Horwitz SM, Green CA, Wisdom JP, Duan N, Hoagwood K. Purposeful Sampling for Qualitative Data Collection and Analysis in Mixed Method Implementation Research. Adm Policy Ment Health. 2015; 42:533-544.

[215] Ritchie J and Lewis J. (Eds.). *Qualitative Research Practice. A Guide for Social Science Students and Researchers*. 2003. London: Sage Publications.

[216] Yehia BR, Fleishman JA, Metlay JP, et al. Comparing different measures of retention in outpatient HIV care. AIDS. 2012;26:1131-1139.

[217] Centers for Disease Control and Prevention. Human immunodeficiency virus (HIV) risk, prevention, and testing behaviors–United States, National HIV Behavioral Surveillance System: men who have sex with men, November 2003-April 2005. 2006. MMWR Surveillance Summary. 55:1–16.

[218] Quintiliani LM, Campbell MK, Haines PS, Webber KH. The Use of the Pile Sort Method in Identifying Groups of Healthful Lifestyle Behaviors among Female Community College Students. J Am Diet Assoc. 2008;108:1503-1507.

[219] Glasner T, van der Vaart W. Applications of calendar instruments in social surveys: a review. Qual Quant. 2009;43:333-349.

[220] Andersen RM. Revisiting the Behavioral Model and Access to Medical Care: Does it Matter? Journal of Health and Social Behavior. 1995;36:1-10.

[221] Andersen R, Bozzette S, Shapiro M, St. Clair P, Morton S, Crystal S, et al. Access of Vulnerable Groups to Antiretroviral Therapy Among Persons in Care for HIV Disease in the United States. Health Services Research. 2000;35(2):389-416.

[222] Andersen RM. National Health Surveys and the Behavioral Model of Health Services Use. Medical Care. 2008;46(7):647-653.

[223] Holtzman CW, Brady KA, Yehia BR. Retention in Care and Medication Adherence: Current Challenges to Antiretroviral Therapy Success. Drugs. 2015;75(5):445-454.

[224] Hawk M, Coulter RWS, Egan JE, Friedman MR, Meanley S, Fisk S, et al. Exploring the Healthcare Environment and Associations with Clinical Outcomes of People Living with HIV/AIDS. AIDS Patient Care and STDs. 2017;31(12):495-503.

[225] Ulett KB, Willig JH, Lin HY, Routman JS, Abroms S, Allison J et al. The Therapeutic Implications of Timely Linkage and Early Retention in HIV Care. AIDS Patient Care and STDs. 2009;23(1):41-49.

[226] Thapa S, Hannes K, Buve A, Bhattarai S, Mathei C. Theorizing the complexity of HIV disclosure in vulnerable populations: a grounded theory study. BMC Public Health. 2018;18:162.

[227] Bradley EH, Curry LA, Devers KJ. Qualitative data analysis for health services research: developing taxonomy, themes, and theory. Health Services Research. 2007;42(4):1758-1772.

[228] Norcini AP, Steca P. Illness perceptions and coping strategies among individuals diagnosed with HIV. J Behav Med. 2015;38:620-631.

[229] Mutumba M, Bauermeister JA, Musiime V, Byaruhanga J, Francis K, Snow RC, et al. Psychosocial Challenges and Strategies for Coping with HIV Among Adolescents in Uganda: A Qualitative Study. AIDS Patient Care and STDs. 2015;29(2):86-94.

[230] Garrido-Hernansaiz H, Murphy PJ, Alonso-Tapia J. Predictors of Resilience and Posttraumatic Growth Among People Living with HIV: A Longitudinal Study. AIDS Behavior. 2017;11:3260-3270.

[231] Aidala AA, Wilson MG, Shubert V, Gogolishvili D, Globerman J, Rueda S, et al. Housing Status, Medical Care, and Health Outcomes Among People Living With HIV/AIDS: A Systematic Review. AJPH. 2016;106(1):e1-e23.

[232] Leaver CA, Bargh G, Dunn JR, Hwang SW. The Effects of Housing Status on Health-Related Outcomes in People living with HIV. A Systematic Review of the Literature. AIDS Behavior. 2007;11:s85-s100.

[233] Remien RH, Hirky AE, Johnson MO, Weinhardt LS, Whittier D, Le GM. Adherence to Medication Treatment: A Qualitative Study of Facilitators and Barriers Among a Diverse Sample of HIV+ Men and Women in Four U.S. Cities. AIDS and Behaviors. 2003;7(1):61-72.

[234] Agwu AL, Fairlie L. Antiretroviral treatment, management challenges, and outcomes in perinatally HIV-infected adolescents. JIAS. 2013;16:18579.

[235] Claborn KR, Meier E, Miller MB, Leffingwell TR. A Systematic Review of Treatment Fatigue among HIV-infected Patients Prescribed Antiretroviral Therapy. Psychol Health Med. 2015;20(3):255-265.

[236] Galea JT, Wong M, Munoz M, Valle E, Leon SR, Perez DD, et al. Barriers and facilitators to antiretroviral therapy adherence among Peruvian adolescents living with HIV: A qualitative study. PLoS ONE. 2018;13(2):e0192791.

[237] Brown JL, Vanable PA, Naughton JD, Carey MP. Identifying HIV-Infected Women's Psychosocial Stressors: Findings from a Qualitative Study. J HIV AIDS Soc Serv. 2015;14(2):188-205.

[238] Kelso-Chichetto NE, Okafor CN, Harman JS, Canidate SS, Cook CL, Cook RL. Complemenary and Alternative Medicine Use for HIV Management in the State of Florida: Medical Monitoring Project. The Journal of Alternative and Complementary Medicine. 2016;22(11):880-886.

[239] Abara W, Heiman HJ. The Affordable Care Act and Low-Income People Living with HIV: Looking Forward in 2014 and Beyond. J Assoc Nurses AID Care. 2014;25(6):476-482.

[240] Noysk B, Lourenco L, Min JE, Shopin D, Lima VD, Montaner JSG. Characterizing retention in HAART as a recurrent event process: insights into 'cascade churn'. AIDS. 2015;29(13):1681-1689.

[241] Colasanti J, Stahl N, Farber EW, del Rio C, Armstrong WS. An Exploratory Study to Assess Individual and Structural Level Barriers Associated with Poor Retention and Re-engagement in Care Among Persons Living With HIV/AIDS. JAIDS. 2017;74(2):S113-S120.

[242] Do AN, Rosenberg ES, Sullivan PS, Beer L, Strine TW, Schulden JD, et al. Excess Burden of Depression among HIV-Infected Persons Receiving Medical Care in the United States: Data from the Medical Monitoring Project and the Behavioral Risk Factor Surveillance System. PLoS ONE. 2014;9(3):e92842.

[243] Ciesla JA, Roberts JE. Meta-Analysis of the Relationship Between HIV Infection and Risk for Depressive Disorders. Am J Psychiatry. 2001;158:725-730.

[244] Guaraldi G, Orlando G, Zona S, Menozzi M, Carli F, Garlassi E, et al. Premature Age-Related Comorbidities Among HIV-Infected Persons Compared With the General Population. Clinical Infectious Diseases. 2011;53(11):1120-1126.

[245] Deeks SG, Phillips AN. HIV infection, antiretroviral treatment, ageing, and non-AIDS related morbidity. BMJ. 2009;338:a3172.

[246] Mimiaga MJ, Reisner SL, Grasso C, Crane HM, Safren SA, Kitahata MM, et al. Substance Use Among HIV-Infected Patients Engaged in Primary Care in the United States: Findings From the Centers for AIDS Research Network of Integrated Clinical Systems Cohort. American Journal of Public Health. 2013;103(8):1457-1467.

[247] Carter A, Roth EA, Ding E, Milloy MJ, Kestler M, Jabbari S, et al. Substance Use, Violence, and Antiretroviral Adherence: A Latent Class Analysis of Women Living with HIV in Canada. AIDS Behavior. 2018;22(3):971-985.

[248] McNair OS, Gipson JA, Denson D, Thompson DV, Sutton MY, Hickson DA. The Associations of Resilience and HIV Risk Behaviors Among Black Gay, Bisexual, Other Men Who Have Sex with Men (MSM) in the Deep South: The MARI Study. AIDS Behavior. 2017; doi: 10.1007/s10461-017-1881-8. [Epub ahead of print].

[249] Dale S, Cohen M, Weber K, Cruise R, Kelso G, Brody L. Abuse and Resilience in Relation to HAART Medication and Adherence and HIV Viral Load Among Women with HIV in the United States. AIDS Patient Care and STDs. 2014;28(3):136-143.

[250] Waddell EN, Messeri PA. Social Support, Disclosure, and Use of Antiretroviral Therapy. AIDS and Behavior. 2006;10(3):263-272.

[251] Kumar S, Mohanraj R, Rao D, Murray KR, Manhart LE. Positive Coping Strategies and HIV-Related Stigma in South India. AIDS Patient Care and STDs. 2015;29(3):157-163.

[252] Boehme AK, Davies SL, Moneyham L, Shrestha S, Schumacher J, Kempf MC. A qualitative study on factors impacting HIV care adherence among postpartum HIV-infected women in rural southeastern USA. AIDS Care. 2014;26(5):574-581.

[253] Bahall M. Prevalence, patterns, and perceived value of complementary and alternative medicine among HIV patients: a descriptive study. BMC Complementary and Alternative Medicine. 2017;17:422.

[254] Littlewood RA, Vanable PA. Complementary and Alternative Medicine Use Among HIV+ People: Research Synthesis and Implications for HIV Care. AIDS Care. 2008; 20(8):1002-1018.

[255] Taiwo B. Understanding transmitted HIV resistance through the experience in the USA. International Journal of Infectious Diseases. 2009;13:552-559.

[256] Soeters HM, Napravnik S, Zakharova OM, Eron JJ, Hurt CB. Opportunities for Sexual Transmission of Antiretroviral Drug Resistance among HIV-Infected Patients in Care. AIDS. 2013;27(18):2873-2881.

[257] Baxter JD, Dunn D, White E, Sharma S, Geretti AM, Kozal MJ, et al. Global HIV-1 transmitted drug resistance in the INSIGHT Strategic Timing of Antiretroviral Treatment (START) trial. HIV Medicine. 2015;16(1):77-87.

[258] Gorbach PM, Javanbakht M, Bornfleth L, Bolan RK, Blum ML. Drug resistant HIV: Behaviors and characteristics among Los Angeles men who have sex with men with new HIV diagnoses. PLoS ONE. 2017;12(3):e0173892.

[259] Yanik EL, Napravnik S, Hurt CB, Dennis A, Quinlivan EB, Sebastian J, et al. Prevalence of Transmitted Antiretroviral Drug Resistance Differs between Acutely and Chronically HIV-Infected Patients. JAIDS. 2012;61(2):258-262.

[260] Viani RM, Peralta L, Aldrovandi G, Kapogiannis BG, Mitchell R, Spector SA, et al. Prevalence of Primary HIV-1 Drug Resistance among Recently Infected Adolescents: A Multicenter Adolescent Medicine Trials Network for HIV/AIDS Interventions Study. The Journal of Infectious Diseases. 2006;194:1505-1509.

[261] Richman DD, Morton SC, Wrin T, Hellmann N, Berry S, Shapiro MF, et al. The prevalence of antiretroviral drug resistance in the United States. AIDS. 2004;18:1393-1401.

[262] Uy J, Armon C, Buchacz K, Wood K, Brooks JT. Initiation of HAART at Higher CD4 Cell Counts Is Associated With a Lower Frequency of Antiretroviral Drug Resistance Mutations at Virologic Failure. JAIDS. 2009;51:450-453.

[263] Deeks SG, Gange SJ, Kitahata MM, Saag MS, Justice AC, Hogg RS, et al. Trends in Multidrug Treatment Failure and Subsequent Mortality among Antiretroviral Therapy-Experienced Patients with HIV Infection in North America. Clinical Infectious Diseases. 2009;49(10):1582-1590.

[264] Cozzi-Lepri A, Phillips AN, Clotet B, Mocroft A, Ruiz L, Kirk O, et al. Detection of HIV drug resistance during antiretroviral treatment and clinical progression in a large European cohort study. AIDS. 2008;22:2187-2198.

[265] Georgia Department of Public Health. Division of Health Protection. Office of HIV/AIDS. Georgia Ryan White Part B, AIDS Drug Assistance Program (ADAP), and Health Insurance Continuation Program (HICP). Policies & Procedures 2017. https://dph.georgia.gov/sites/dph.georgia.gov/files/related_files/site_page/FY2017%20GA%20RW-ADAP-HICP%20Policies%20and%20Procedures%20%28March%202017%29.pdf. Published March 2017. Accessed March 31, 2018.

[266] Olson KM, Godwin NC, Wilkins SA, Mugavero MJ, Moneyham LD, Slater LZ, et al. A Qualitative Study of Underutilization of the AIDS Drug Assistance Program. J Assoc Nurses AIDS Care. 2014;25(5):392-404.

[267] Wohl DA, Kuwahara RK, Javadi K, Kirby C, Rosen DL, Napravnik S, et al. Financial Barriers and Lapses in Treatment and Care of HIV-Infected Adults in a Southern State in the United States. AIDS Patient Care and STDs. 2017;31(11):463-469.

[268] National ADAP Monitoring Project: 2017 Annual Report. https://www.nastad.org/sites/default/files/nas001_report_v6_singlepages.pdf. Accessed March 31, 2018.

[269] Kassaye SG, Grossman Z, Balamane M, Johnston-White B, Liu C, Kumar P, et al.

Transmitted HIV Drug Resistance is High and Longstanding in Metropolitan Washington, DC. Clinical Infectious Diseases. 2016;63(6):836-843.

[270] Buettgans M, Nichols A, Dorn S. Churning Under the ACA and State Policy Options for Mitigration. Timely Analysis of Immediate Health Policy Issues. June 2012. https://www.urban.org/sites/default/files/publication/25496/412587-Churning-under-the-ACA-and-State-Policy-Options-for-Mitigation.PDF. Accessed March 31, 2018.

[271] Committee on Public Financing and Delivery of HIV Care. *Public Financing and Delivery of HIV/AIDS Care – Securing the Legacy of Ryan White*. 2005. Washington DC: The National Academies Press.

[272] Grov C, Golub SA, Parson JT, Brennan M, Karpiak SE. Loneliness and HIV-related stigma explain depression among older HIV-positive adults. AIDS Care. 2010;22(5):630-639.

[273] Foote-Ardah CE. The meaning of complementary and alternative medicine practices among people with HIV in the United States: strategies for managing everyday life. Sociology of Health and Ilness. 2003;25(5):481-500.

[274] Muessig KE, Panter AT, Mouw MS, Amola K, Stein KE, Murphy JS, et al. Medication-Taking Practices of Patients on Antiretroviral HIV Therapy: Control, Power, and Intentionality. AIDS Patient Care and STDs. 2015;29(11):606-616.

[275] Maulsby C, Millett G, Lindsey K, Kelley R, Johnson K, Montoya D, et al. HIV Among Black Men Who Have Sex with Men (MSM) in the United States: A Review of the Literature. AIDS Behavior. 2014;18:10-25.

[276] Yoon IS, Downing Jr. MJ, Teran R, Chiasson MA, Houang ST, Parsons JT, et al. Sexual risk taking and the HIV care continuum in an online sample of men who have sex with men. AIDS Care. 2017;30(7):921-929.

[277] Friedman MR, Stall R, Plankey M, Wei C, Shoptaw S, Herrick A, et al. Effects of Syndemics on HIV Viral Load and Medication Adherence in the Multicenter AIDS Cohort Study. AIDS. 2015;29(9):1087-1096.

[278] Mugavero MJ, Westfall AO, Zinski AZ, Davila J, Drainoni ML, Gardner LI, et al. Measuring Retention in HIV Care: The Elusive Gold Standard. JAIDS. 2012;61(5):574-580.

[279] Maulsby C, Millett G, Lindsey K, Kelley R, Johnson K, Montoya D, et al. A systematic review of HIV interventions for black men who have sex with men (MSM). BMC Public Health. 2013;13:625.

[280] Centers for Disease Control and Prevention. Compendium of Evidence-Based Interventions and Best Practices for HIV Prevention. Linkage to, Retention in, and Re-engagement in HIV Care (LRC) Chapter. Updated on March 24,2017. https://www.cdc.gov/hiv/research/interventionresearch/compendium/index.html. Accessed on July, 16, 2018.

[281] Rao D, Feldman BJ, Frederickson RJ, Crane PK, Simoni JM, Kitahata MM, et al. A Structural Equation Model of HIV-Related Stigma, Depressive Symptoms, and Medication Adherence. AIDS Behavior. 2012;16(3):711-716.

[282] Bogart LM, Dale SK, Christian J, Patel K, Daffin GK, Mayer KH, et al. Coping with discrimination among HIV-positive Black men who have sex with men. Culture, Health, & Sexuality. 2017;19(7):723-737.

[283] Swartz K, Short PF, Graefe DR, Uberoi N. Evaluating State Options for Reducing Medicaid Churning. Health Aff (Millwood). 2015;34(7):1180-1187.

[284] Garfield R, Damico A, Orgera K. The Coverage Gap: Uninsured Poor Adults in States that Do Not Expand Medicaid. Henry J Kaiser Family Foundation. Published June 12, 2018.

https://www.kff.org/medicaid/issue-brief/the-coverage-gap-uninsured-poor-adults-in-states-that-do-not-expand-medicaid/. Accessed June 28, 2018.

[285] Centers for Disease Control and Prevention. *HIV Surveillance Report, 2016*; vol. 28. http://www.cdc.gov/hiv/library/reports/hiv-surveillance.html. Published November 2017. Accessed July 11, 2018.

[286] Peterson JL, Jones KT. HIV Prevention for Black Men Who Have Sex With Men in the United States. AJPH. 2009;99(6):976-980.

[287] Sikkema KJ, Wilson PA, Hansen NB, Kochman A, Neufeld S, Ghebremichael MS, et al. Effects of a Coping Intervention on Transmission Risk Behavior Among People Living With HIV/AIDS and a History of Childhood Sexual Abuse. JAIDS, 2008;47(4):506-513.

[288] Sweeney SM, Vanable PA. The Association of HIV-Related Stigma to HIV Medication Adherence: A Systematic Review and Synthesis of the Literature. AIDS Behavior. 2016;20:29-50.

[289] Koenig LJ, Pals SL, Bush T, Pallmore MP, Stratford D, Ellerbrock TV. Randomized Controlled Trial of an Intervention to Prevent Adherence Failure Among HIV-Infected Patients Initiating Antiretroviral Therapy. Health Psychology. 2008;27(2):159-169.

[290] The Healthy Living Project Team. Effects of a Behavioral Intervention to Reduce Risk of Transmission Among People Living With HIV. JAIDS. 2007;44(2):213-221.

[291] Cassells S, Katz DA. Seroadaptation among Men Who Have Sex with Men: Emerging Research Themes. Curr HIV/AIDS Rep. 2013;10(4):305-313.

[292] Baral S, Logie CH, Grosso A, Wirtz AL, Beyrer C. Modified social ecologic model: a tool to guide the assessment of the risks and risk contexts of HIV epidemics. BMC Public Health. 2013;13:482.

[293] Whiteside A, Hickey A, Ngcobo N, Tomlinson J. What is driving the HIV/AIDS epidemic in Swaziland and what more can we do about it? National Emergency Response Committee on HIV/AIDS. UNAIDS. Published April 2003.

[294] Ferrer R and Klein WM. Risk perception and health behavior. Curr Opin Psychol. 2015;5:85-89.

[295] Brewer NT, Chapman GB, Gibbons FX, Gerrard M, McCaul KD, Weinstein ND. Meta-analysis of the relationship between risk perception and health behavior: the example of vaccination. Health Psychology. 2007;26(2):136-145.

[296] Sheeran P, Harris PR, Epton T. Does Heightening Risk Appraisals Change People's Intentions and Behavior? A Meta-Analysis of Experimental Studies. Psychological Bulletin. 2014;140(2):511-543.

[297] Kurth AE, Spielberg F, Cleland CM, Lambdin B, Bangsberg DR, Frick PA, et al. Computerized Counseling Reduces HIV-1 Viral Load and Sexual Transmission Risk: Findings from a Randomized Controlled Trial. JAIDS. 2014;65(5):611-620.

[298] Remien RH, Stirratt MJ, Dolezal C, Dognin JS, Wagner GJ, Carballo-Dieguez A, et al. Couple-focused support to improve HIV medication adherence: a randomized controlled trial. AIDS. 2005;19:807-814.

[299] N, Jemmott JB, Landis JR, Pequegnat W, Wingood GM, Wyatt GE, et a. National Institute of Mental Health Multisite Eban HIV/STD Prevention Intervention for African American HIV Serodiscordant Couples: A Cluster Randomized Trial. Arch Intern Med. 2010;170(17):1594-1601.

[300] Kegeles SM, Hays RB, Coates TJ. The Mpowerment Project: A Community-Level HIV Prevention Intervention for Young Gay Men. American Journal of Public Health. 1996;86(8):1129-1136.

[301] Walensky RP, Ross EL, Kumarasamy N, Wood R, Noubary F, Paltiel AD, et al. Cost-Effectiveness of HIV Treatment as Prevention in Serodiscordant Couples. NEJM. 2013;369:1715-1725.

[302] Kahn JG, Marseille EA, Bennett R, Williams BG, Granich R. Cost-Effectiveness of Antiretroviral Therapy for Prevention. Current HIV Research. 2011;9:405-415.

[303] Risa KJ, Nepon L, Justis JC, Panwalker A, Berman SM, Citi S, et al. Alternative therapy use in HIV-infected patients receiving highly active antiretroviral therapy. International Journal of STD & AIDS. 2002;13:706-713.

[304] Kirksey KM, Goodroad BK, Kemppainen JK, Holzemer WL, Bunch EH, Corless IB, et al. Complementary Therapy Use in Persons with HIV/AIDS. Journal of Holistic Nursing. 2002;20(3):264-278.

[305] Sheehan DM, Trepka MJ, Fennie KP, Prado G, Ibanez G, Maddox LM. Racial/ethnic disparities in delayed HIV diagnosis among men who have sex with men, Florida, 2000-2014. AIDS Care. 2017;29(3):311-318

[306] Nelson KM, Thiede H, Hawes SE, Golden MR, Hutcheson R, Carey JW, et al. Why The Wait? Delayed HIV Diagnosis among Men Who Have Sex with Men. Journal of Urban Health. 2010;87(4):642-655.

[307] Campbell CK, Lippman SA, Moss N, Lightfoot M. Strategies to Increase HIV Testing Among MSM: A Synthesis of the Literature. AIDS and Behavior. 2018;22:2387-2412.

[308] Cooley LA, Oster AM, Rose CE, Wejnert C, Le BC, Paz-Bailey G. Increases in HIV Testing among Men Who Have Sex with Men – National HIV Behavioral Surveillance System, 20 U.S. Metropolitan Statistical Areas, 2008 and 2011. PLoS ONE. 2014;9(9):e104162.

[309] Quinn K, Voisin DR, Bouris A, Jaffe K, Kuhns L, Eavou R, et al. Multiple Dimensions of Stigma and Health Related Factors Among Young Black Men Who Have Sex with Men. AIDS Behavior. 2017;21(1):207-216.

[310] Johnson MO, Charlebois E, Morin SF, Remien RH, Chesney MA. Effects of a behavioral intervention on antiretroviral medication adherence among people living with HIV: The Healthy Living Project randomized controlled study. JAIDS. 2007;46(5):574-580.

[311] Stangl AL, Lloyd JK, Brady LM, Holland CE, Baral S. A systematic review of interventions to reduce HIV-related stigma and discrimination from 2002 to 2013: how far have we come. JIAS. 2013;16(Suppl 2):18734.

[312] Katz IT, Ryu AE, Onuegbu AG, Psaros C, Weiser SD, Bangsberg DR, et al. Impact of HIV-related stigma on treatment adherence: systematic review and meta-synthesis. JIAS. 2013;16(Suppl 2):18640.

[313] Rao D, Desmond M, Andrasik M, Rasberry T, Lambert N, Cohn SE, et al. Feasibility, Acceptability, and Preliminary Efficacy of the Unity Workshop: An Internalized Stigma Reduction Intervention for African-American Women Living with HIV. AIDS Patient Care and STDs. 2012;26(10):614-620.

[314] Hosek SG, Lemos D, Harper GW, Telander K. Evaluating the acceptability and feasibility of Project ACCEPT: an intervention for youth newly diagnosed with HIV. AIDS Educ Prev. 2011;23(2):128-144.

[315] Logie CH, Lacombe-Duncan A, Wang Y, Kaida A, Conway T, Webster K, et al. Pathways From HIV-Related Stigma to Antiretroviral Therapy Measures in the HIV Care Cascade for Women Living With HIV in Canada. JAIDS. 2018;77(2):144-153.

[316] Mall S, Middelkoop K, Mark D, Wood R, Bekker LG. Changing patterns in HIV/AIDS stigma and uptake of voluntary counseling and testing services: The results of two consecutive community surveys conducted in the Western Cape, South Africa. AIDS Care. 2013;25(2):194-201.

[317] Simoni JM, Pantalone DW, Plummer MD, Huang B. A Randomized Controlled Trial of a Peer Support Intervention Targeting Antiretroviral Medication Adherence and Depressive Symptomatology in HIV-Positive Men and Women. Health Psychology. 2007;26(4):488-495.

[318] Simoni JM, Huh D, Frick PA, Pearson CR, Andrasik MP, Dunbar PJ, et al. An RCT of Peer Support and Pager Messaging to Promote Antiretroviral Therapy Adherence and Clinical Outcomes among Adults Initiating or Modifying Therapy in Seattle, WA, USA. JAIDS. 2009;52(4):465-473.

APPENDICES

APPENDIX A. INVOLVEMENT SURVEY QUESTIONS

HIV Risk Perception:

48. You have met a man with whom you want to have sex and you don't know his HIV status .

Please rate how safe/unsafe you personally consider each of these sexual practices to be for you. Below are a number of sexual practices and a scale from 1 (completely safe) to 10 (completely risky). Please indicate the number that represents your view of how safe or risky each practice is for your health.

	Completely safe 1	2	3	4	5	6	7	8	9	Completely risky 10
You are the insertive partner during anal intercourse without a condom	○	○	○	○	○	○	○	○	○	○
You are the insertive partner during condom-protected anal intercourse	○	○	○	○	○	○	○	○	○	○
You are the receptive partner during anal intercourse without a condom	○	○	○	○	○	○	○	○	○	○
You are the receptive partner during condom-protected anal intercourse	○	○	○	○	○	○	○	○	○	○
You perform oral sex on a partner who cums in your mouth without a condom	○	○	○	○	○	○	○	○	○	○
You perform oral sex on a partner WHO doesn't cum in your mouth	○	○	○	○	○	○	○	○	○	○
Partner performs oral sex on you	○	○	○	○	○	○	○	○	○	○
You engage in non-penetrative sex (mutual masturbation) until you and your partner cum	○	○	○	○	○	○	○	○	○	○
	1	2	3	4	5	6	7	8	9	10

53. Earlier we asked you some questions about how safe some activities would be with a partner whose HIV status you did not know.

Now, please imagine that you have met a man with whom you want to have sex and he is HIV-negative.

Please rate how safe/unsafe you personally consider each of these sexual practices to be for you.

Below are a number of sexual practices and a scale from 1 (completely safe) to 10 (completely risky). Please indicate the number that represents your view of how safe or risky each practice is for your health.

	Completely safe 1	2	3	4	5	6	7	8	9	Completely risky 10
You are the insertive partner during anal intercourse without a condom	○	○	○	○	○	○	○	○	○	○
You are the insertive partner during condom-protected anal intercourse	○	○	○	○	○	○	○	○	○	○
You are the receptive partner during anal intercourse without a condom	○	○	○	○	○	○	○	○	○	○
You are the receptive partner during condom-protected anal intercourse	○	○	○	○	○	○	○	○	○	○
You perform oral sex on a partner who cums in your mouth without a condom	○	○	○	○	○	○	○	○	○	○
You perform oral sex on a partner who doesn't cum in your mouth	○	○	○	○	○	○	○	○	○	○
Partner performs oral sex on you	○	○	○	○	○	○	○	○	○	○
You engage in non-penetrative sex (mutual masturbation) until you and your partner cum	○	○	○	○	○	○	○	○	○	○
	1	2	3	4	5	6	7	8	9	10

58. Earlier we asked you some questions about how safe some sexual activities would be with partners who were HIV-negative or whose HIV status you did not know.

Now the question changes a litte.

Now, please imagine that you have met someone with whom you want to have sex and is HIV-positive, but taking antiretroviral medications that reduced his viral load to an undetectable level.

Please rate how safe/unsafe you personally consider each of these sexual practices to be for you.

Below are a number of sexual practices and a scale from 1 (completely safe) to 10 (completely risky). Please indicate the number that represents your view of how safe or risky each practice is for your health.

	Completely safe 1	2	3	4	5	6	7	8	9	Completely risky 10
You are the insertive partner during anal intercourse without a condom	○	○	○	○	○	○	○	○	○	○
You are the insertive partner during condom-protected anal intercourse	○	○	○	○	○	○	○	○	○	○
You are the receptive partner during anal intercourse without a condom	○	○	○	○	○	○	○	○	○	○
You are the receptive partner during condom-protected anal intercourse	○	○	○	○	○	○	○	○	○	○
You perform oral sex on a partner who cums in your mouth without a condom	○	○	○	○	○	○	○	○	○	○
You perform oral sex on a partner who doesn't cum in your mouth	○	○	○	○	○	○	○	○	○	○
Partner performs oral sex on you	○	○	○	○	○	○	○	○	○	○
You engage in non-penetrative sex (mutual masturbation) until you and your partner cum	○	○	○	○	○	○	○	○	○	○
	1	2	3	4	5	6	7	8	9	10

61. Earlier we asked some questions about how safe you think some sexual activities are with different kinds of partners.

We have one more scenario to ask about.

This time, please imagine that you have met a man with whom you want to have sex and he is HIV-positive and not taking antiretroviral medications.

Please rate how safe/unsafe you personally consider each of these sexual practices to be for you.

Below are a number of sexual practices and a scale from 1 (completely safe) to 10 (completely risky). Please indicate the number that represents your view of how safe or risky each practice is for your health.

	Completely safe 1	2	3	4	5	6	7	8	9	Completely risky 10
You are the insertive partner during anal intercourse without a condom	○	○	○	○	○	○	○	○	○	○
You are the insertive partner during condom-protected anal intercourse	○	○	○	○	○	○	○	○	○	○
You are the receptive partner during anal intercourse without a condom	○	○	○	○	○	○	○	○	○	○
You are the receptive partner during condom-protected anal intercourse	○	○	○	○	○	○	○	○	○	○
You perform oral sex on a partner who cums in your mouth without a condom	○	○	○	○	○	○	○	○	○	○
You perform oral sex on a partner who doesn't cum in your mouth	○	○	○	○	○	○	○	○	○	○
Partner performs oral sex on you	○	○	○	○	○	○	○	○	○	○
You engage in non-penetrative sex (mutual masturbation) until you and your partner cum	○	○	○	○	○	○	○	○	○	○
	1	2	3	4	5	6	7	8	9	10

Condom Attitudes with a New Partner:

50. The following statements ask how much you approve or disapprove of some ideas about condom use.

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve
Abstaining from sexual intercourse if condoms are not used by a new partner	○	○	○	○	○
Insisting on condom use even if your new partner does not want to use a condom	○	○	○	○	○
Not using a condom during sexual intercourse with a new partner	○	○	○	○	○

HIV Knowledge:

59. The next set of questions ask about your HIV knowledge. For each statement, please click "True", "False", or "I don't know." If you do not know, please do not guess; instead, please click the button: "I don't know."

	True	False	Don't Know
Coughing and sneezing DO NOT spread HIV.	○	○	○
A person can get HIV by sharing a glass of water with someone who has HIV.	○	○	○
Pulling out the penis before a man climaxes/cums keeps his partner from getting HIV during sex.	○	○	○
A woman can get HIV if she has anal sex with a man.	○	○	○
Showering, or washing one's genitals/private parts, after sex keeps a person from getting HIV.	○	○	○
All pregnant women infected with HIV will have babies born with AIDS.	○	○	○
People who have been infected with HIV quickly show serious signs of being infected.	○	○	○
There is a vaccine that can stop adults from getting HIV.	○	○	○
People are likely to get HIV by deep kissing (putting their tongue in their partner's mouth), if their partner has HIV.	○	○	○
A woman cannot get HIV if she has sex during her period.	○	○	○
There is a female condom that can help decrease a woman's chance of getting HIV.	○	○	○
A natural skin condom works better against HIV than does a latex condom.	○	○	○
A person will NOT get HIV if he is taking antibiotics.	○	○	○
Having sex with more than one partner can increase a person's chance of becoming infected with HIV.	○	○	○
Taking a test for HIV one week after having sex will tell a person if she or he has HIV.	○	○	○
A person can get HIV by sitting in a hot tub or a swimming pool with a person who has HIV.	○	○	○
A person can get HIV from oral sex.	○	○	○
Using Vaseline or baby oil with condoms lowers the chance of getting HIV.	○	○	○

HIV Testing History:

62. Have you ever been tested for HIV?

1 ○ Yes If yes, then #63, #64, #65, #66

0 ○ No

HIVtest_ever

63. In what month and year did you have your most recent HIV test?

Month:

January	=1
February	=2
March	=3
April	=4
May	=5
June	=6
July	=7
August	=8
September	=9
October	=10
November	=11
December	=12

HIVtest_month

HIVtest_month.

64. Year: HIVtest_year

Number of Sex Partners (past 6 months):

109 During the last 6 months, with how many men did you have anal or oral sex?:

_____ male_howmanyp6m if 0=#123

111 During the last 6 months, with how many women did you have vaginal or anal sex?:

_____ female_howmanyp6m

113 During the last 6 months, with how many male to female transgender individuals did you have sex?:

_____ mtf_howmanyp6m

115 During the last 6 months, with how many female to male transgender individuals did you have sex?:

_____ ftm_howmanyp6m

Aggregated Behaviors with Male Partners (in past 6 months):

117 Of the [%%45:%%] male partners you had anal or oral sex with in the last 6 months, how many were:

[ ] main partners? (someone that you feel committed to above all others -- this is someone you might call your boyfriend, significant other, life partner, or husband) male_mainp6m

[ ] casual partners? (someone that you do not feel committed to above all others.) male_casualp6m

121 Of your [%%49:Of the [%% %%] partners you had anal sex with in the last 6 months, how many did you have unprotected anal sex with? (This means that you or your partner did not use a condom at any point during sex, at least one time that you had anal sex).

_____ males_UAIp6m

Partner-Specific Behaviors with Male Partners (in past 6 months):

214 Is/was [%%454:cur_partner_nam %%] someone that you feel or felt committed to above all others (someone you might call your boyfriend, significant other, life partner, or husband)? mainP1

0 ( ) Yes
1 ( ) No
9 ( ) Don't know
REQUIRED

if #95,#97,#99,#101=yes, then #215
if #95,#97,#99,#101=no or 9, then #216

Did you and [%%454:cur_partner_nam %%] share both of your HIV statuses before you had sex? discussstatusfsP1

1 ( ) Yes
0 ( ) No
9 ( ) Don't know
discussstatusfsP1 – P5

if yes then #222

222 *If 'yes' to discussing status:*

What was [%%454:cur_partner_nam %%]'s status at that time? statusfsP1

1 HIV-negative
0 HIV-positive
9 Don't know

statu: 1 – P5

if pos or neg, then #223
if don't know, then #225

271 The last time you had sex with [%%454:cur_partner_nam %%], did you know his/her HIV status?
1 Yes
0 No
9 Don't know
VstatknowIsP1 - P5

HIVstatIsP1

If yes:
272 What was [%%454:cur_partner_nam %%]'s HIV status at that time?
( ) HIV-negative **"HIV-negative"**
( ) HIV-positive **"HIV-positive"**
HIVstatIsP1 – P5

HIVstatsourceIsP1

239 *If 'yes'*
Have you had unprotected anal sex with [%%454:cur_partner_nam %%] in the last 6 months? *(This means that you or* [%%454:cur_partner_nam %%] *did not use a condom at any point during sex, at least one time that you had anal sex.)*
1 Yes
2 No
9 Don't know
UAImpP1 - P5

UAImpP1

255 The last time you had sex with [%%454:cur_partner_nam %%], did you have receptive anal sex? (This means that you were the bottom)
1 Yes
0 No
9 Don't know
RAIIsP1 – P5

RAIIsP1

If 'yes'
256 Did [%%454:cur_partner_nam %%] use a condom the last time you had receptive anal sex (when you were the bottom)?
1 [%%454:cur_partner_nam %%] did not use a condom **1**
2 [%%454:cur_partner_nam %%] used a condom part of the time **2**
3 [%%454:cur_partner_nam %%] used a condom the whole time **3**
4 [%%454:cur_partner_nam %%] used a condom, but it broke **4**
9 Don't know **9**
RAIIscondomP1 – P5

RAIIscondomP1

258 The last time you had sex with [%%454:cur_partner_nam %%], did you have insertive anal sex? (This means that you were the top).
1 Yes
0 No
9 Don't know
IAIsP1 – P5

IAIsp1

If 'yes'
259 Did you use a condom the last time you had insertive anal sex with [%%454:cur_partner_nam %%] (when you were the top)?
1 I did not use a condom **1**
2 I used a condom part of the time **2**
3 I used a condom the whole time **3**
4 I used a condom, but it broke **4**
9 Don't know **9**
IIscondomP1 – P5

IAIscondomP1

APPENDIX B. ADDITIONAL ANALYSES

Aim 1: Comparing Validation Results of Partner vs. Participant-Level Covariates

	Type 3 p-value (unadjusted)	
	Participant-level	**Partner-level**
Condom attitudes (new partner)	n/a	n/a
HIV knowledge	n/a	n/a
HIV testing frequency	n/a	n/a
Partner status (partner-level)	-	0.0094
HIV+ partner (participant-level)	0.0111	-
HIV? partner (participant-level)	0.0082	-
Partner type (partner-level)	-	0.5442
Main partner (participant-level)	0.4190	-
Casual partner (participant-level)	0.5275	-
CAI (partner-level)	-	0.5347
CAI (participant-level)	0.3332	-
# sex partners	n/a	n/a
Receptive CAI (partner-level)	-	0.6626
Insertive CAI (partner-level)	-	0.5304
Receptive CAI (participant-level)	0.8912	-
Insertive CAI (participant-level)	0.3094	-

Aim 1: Item Response Probabilities for 3-Class Latent Model

Classes	1 - Low Perceived Risk			2 - Condom Determined/Fully Informed Risk			3 – Status-Derived Risk/High Perceived Risk		
Probability of Membership	11.3%			44.5%					
Levels	Low	Medium	High	Low	Medium	High	Low	Medium	High
Indicators									
Item Response Probabilities									
HIV- PIAI	84.9	13.2	1.9	97.0	3.0	0.0	78.6	16.1	5.3
HIV- PRAI	84.8	11.4	3.8	91.5	7.1	1.4	64.6	26.3	9.1
HIV- UIAI	82.6	15.3	2.1	37.1	28.3	34.6	33.8	20.7	45.5
HIV- URAI	71.5	21.1	7.5	16.9	26.9	56.2	19.8	23.1	57.1
HIV? PIAI	79.5	13.1	7.5	97.4	2.1	0.6	72.5	21.4	6.1
HIV? PRAI	80.1	17.8	2.1	83.7	14.3	2.0	48.9	33.5	17.6
HIV? UIAI	66.8	25.1	8.1	14.9	29.1	56.1	10.0	20.2	69.7
HIV? URAI	51.5	18.5	30.1	4.5	1.3	94.3	4.9	5.6	89.6
HIV+(arv) PIAI	87.4	8.8	3.9	80.3	19.2	0.6	5.3	31.3	63.4
HIV+(arv) PRAI	76.4	11.2	12.4	60.2	35.7	4.0	0.6	22.3	77.1
HIV+(arv) UIAI	80.8	13.9	5.3	8.0	21.2	70.8	0.0	5.0	95.0
HIV+(arv) URAI	59.5	16.2	24.2	1.0	4.0	95.0	0.0	3.8	96.2
HIV+(no arv) PIAI	78.2	12.3	9.6	53.3	41.1	5.6	0.6	8.9	90.6
HIV+(no arv) PRAI	72.2	14.8	13.0	40.0	42.6	17.4	0.0	3.8	96.2
HIV+(no arv) UIAI	63.3	20.5	16.2	0.0	10.0	90.0	0.0	0.5	99.5
HIV+(no arv) URAI	48.4	13.0	38.5	0.5	0.0	99.5	0.0	1.0	99.0

Aim 1: 3-Class Latent Model Validation

	Low Perceived Risk (Class 1)	Status-derived Risk Perception/High Perceived Risk (Class 3)
	OR (95% CI)	
Positive Condom Attitudes w/ New Partner	0.16 (0.07, 0.37)	0.63 (0.30, 1.32)
Negative Condom Attitudes w/ New Partner	-	-
type 3 p-value < 0.0001		
Low HIV Knowledge	2.41 (1.27, 4.57)	1.60 (1.09, 2.36)
High HIV knowledge	-	-
type 3 p-value = 0.0063		
Never Tested for HIV/Tested over 1 yr. ago	2.24 (1.18, 4.23)	0.98 (0.62, 1.54)
Tested for HIV within 1 yr. of baseline visit	-	-
type 3 p-value = 0.0279		
Sex w/ HIV? Partner	0.90 (0.43, 1.85)	0.78 (0.51, 1.20)
Sex w/ HIV+ Partner	1.03 (0.35, 2.97)	0.27 (0.13, 0.56)
Sex w/ HIV- Partner	-	-
type 3 p-value = 0.0103 (partner-level)		
Sex w/ any HIV+ Partner	0.72 (0.28, 1.82)	0.28 (0.14, 0.59)
No sex w/ HIV+ Partner	-	-
type 3 p-value = 0.0033 (participant-level)		
Sex w/ any HIV? Partner	0.61 (0.33, 1.11)	0.79 (0.54, 1.17)
No sex w/ HIV? Partner	-	-
type 3 p-value = 0.2141 (participant-level)		
Sex w/ any HIV- Partner	0.84 (0.37, 1.88)	1.21 (0.69, 2.11)
No sex w/ HIV- Partner	-	-
type 3 p-value = 0.6333 (participant-level)		
Aware of Partner's HIV Status	1.06 (0.65, 1.74)	1.11 (0.83, 1.51)
Not Aware of Partner's HIV Status	-	-
type 3 p-value = 0.7778 (partner-level)		
Not Aware of All Partners' HIV Status	0.70 (0.38, 1.30)	0.81 (0.55, 1.20)
Aware of All Partners' HIV Status	-	-
type 3 p-value = 0.4098 (participant-level)		

CAI	1.39 (0.89, 2.18)	0.93 (0.71, 1.23)
No CAI	-	-
type 3 p-value = 0.2764 (partner-level)		
Any CAI	1.00 (0.51, 1.95)	0.77 (0.51, 1.16)
No CAI	-	-
type 3 p-value = 0.4255 (participant-level)		
Main Partner	1.56 (1.01, 2.40)	1.27 (0.97, 1.65)
Casual Partner	-	-
type 3 p-value = 0.0774 (partner-level)		
Sex w/ any main partner	1.68 (0.87, 3.24)	1.27 (0.85, 1.88)
Sex w/ no main partners	-	-
type 3 p-value = 0.2300 (participant-level)		
Sex w/ any casual partner	0.34 (0.09, 1.27)	0.71 (0.24, 2.08)
Sex w/ no casual partners	-	-
type 3 p-value = 0.2740 (participant-level)		
>5 sex partners in past 6 mo.	0.90 (0.45, 1.77)	1.06 (0.70, 1.62)
1-5 sex partners in past 6 mo.	-	-
type 3 p-value = 0.8744 (participant-level)		
Receptive CAI in past 6 mo.	2.54 (1.42, 4.54)	1.56 (1.06, 2.30)
No RCAI in past 6 mo.	-	-
type 3 p-value = 0.0094 (partner-level)		
Any Receptive CAI	1.68 (0.88, 3.18)	1.43 (0.94, 2.19)
No Receptive CAI	-	-
type 3 p-value = 0.1408 (participant-level)		
Insertive CAI in past 6 mo.	1.04 (0.54, 2.01)	0.76 (0.54, 1.08)
No ICAI in past 6 mo.	-	-
type 3 p-value = 0.2818 (partner-level)		
Any Insertive CAI	0.77 (0.41, 1.47)	0.78 (0.53, 1.17)
No Insertive CAI	-	-
type 3 p-value = 0.4407 (participant-level)		

Class 2: Condom-derived/Fully Informed risk perceivers = referent group

RERI Calculation – Motivational CAI (Race Interaction):

	RR	SE(RR)	Var(RR)
RR11 (effect of low perceived risk, white partner vs. seroadaptor, black partner)	1.3539	0.106	0.011236
RR10 (effect of low perceived risk, black partner vs. seroadaptor, black partner)	1.0157	0.111	0.012321
RR01 (effect of seroadaptor, white partner vs. seroadaptor, black partner)	0.9936	0.0838	0.00702244
RR00 (effect of seroadaptor, black partner vs. seroadaptor, black partner)	1		

	COV (model)	COV (emp)
covariance b/w low perceived risk, white partner vs. low perceived risk, black partner (RR11 vs. RR10)	0.004815	0.004001
covariance b/w low perceived risk, white partner vs. seroadaptor, white partner (RR11 vs. RR01)	0.005243	0.004524
covariance b/w low perceived risk, black partner vs. seroadaptor, white partner (RR10 vs. RR01)	0.004553	0.003802

RERI = RR11 - RR10 - RR01 + RR00	**0.3446**	
RERI(SE) = sqrt ((RR11^2*Var(RR11)) + (RR10^2*Var(RR10)) + (RR01^2*Var(RR01)) + (2*RR11*RR10*COV(RR11, RR10)) + (2*RR11*RR01*COV(RR11, RR01)) + (2*RR10*-RR01*COV(RR10, RR01)))		
RR11^2*Var(RR11)	0.020596096	0.020596096
RR10^2*Var(RR10)	0.012710916	0.012710916
RR01^2*Var(RR01)	0.00693284	0.00693284
2*RR11*RR10*COV(RR11, RR10)	0.013242754	0.011004
2*RR11*RR01*COV(RR11, RR01)	0.014106135	0.012171687
2*RR10*RR01*COV(RR10, RR01)	0.009189771	0.007673953
Sum	0.076778513	0.071089493
RERI(SE)	0.277089359	0.266626129

	lb (model)	ub (model)
95% CI: RERI	**-0.198495143**	**0.887695143**
	lb (emp)	ub (emp)
	-0.177987213	**0.867187213**

Proportion of the Variance of the Outcomes Explained by Latent Typologies of Perceived Risk:

Motivational Hypothesis	Variance estimate for random intercept	ICC
CAI Outcome w/ all covariates except latent measure of perceived risk (Model 1)	1.7144	0.342578531
Model 1 including latent measure of perceived risk (no interaction terms)	1.6982	0.340443447
Model 1 including latent measure of perceived risk and race interaction	1.6628	0.335729284
Model 1 including latent measure of perceived risk and partner type interaction	1.6753	0.337401567
Model 1 including latent measure of perceived risk and partner status interaction	1.702	0.340945513
Status Awareness Outcome w/ all covariates except latent measure of perceived risk (Model 2)	2.795	0.459326212
Model 2 including latent measure of perceived risk (no interaction terms)	2.73	0.453488372
Model 2 including latent measure of perceived risk and race interaction	2.6545	0.446547229
Model 2 including latent measure of perceived risk and partner type interaction	2.7354	0.453978159

Reflective Hypothesis	Cox-Snell R-Squared	Max-Rescaled R-Squared
Model without latent measure of perceived risk	0.1245	0.1752
Model w/ latent measure of perceived risk	0.1278	0.1798

APPENDIX C. PREVIOUS LITERATURE ON AIMS 1 AND 2

List of Studies Evaluating the Relationship between HIV Risk Perception and Condom Use:

Author/Yr	Study Population/ Region	Study Design	Type of Question [A]	Perceived Risk Questions	Type of Outcome	Result [B]
Baume, 2000 [145]	Teenagers USA	Cross-sectional	Unconditional, Global	"How likely do you think it is that you could get HIV/AIDS in the next 5 years?"	Condom use frequency (retrospective assessment)	Negative Statistically significant
Belcher, 2005 [139]	HIV+ MSM USA	Cross-sectional	Conditional, Global	Rate your risk of transmitting HIV to an HIV-negative sex partner when you are engaging in insertive anal intercourse: 1. With condom 2. Without condom, no ejaculation 3. Without condom, ejaculation 4. Without condom, with ejaculation, taking protease inhibitor 5. Without condom, with ejaculation, have undetectable viral load	Insertive, condomless anal intercourse (CAI) with HIV-negative partners (in past 3 months)	Positive 4/5 measures not statistically significant
Chard, 2017 [150]	MSM Australia, Brazil, Canada, South Africa, Thailand, UK, USA	Cross-sectional	Unconditional, Global	"How would you rate your risk for contracting HIV based on your current behaviors?"	CAI% (in past year)	Positive (6/8 countries) Not statistically significant in 7/8 countries
Fan, 2014 [151]	HIV- or HIV? MSM	Cross-sectional	Unconditional, Global	"How large do you think the risk of being infected with HIV?"	CAI (in past 6 months)	Negative

	China					Not statistically significant
Holtzman, 2001 [138]	Adults, 18 yrs. Or older USA	Cross-sectional	Unconditional, Global	"What are your chances of getting infected with HIV, the virus that causes AIDS?"	Condom use at last intercourse in past year	Positive No significance testing
Kalichman, 2007 [135]	HIV-, HIV+, and HIV? MSM USA	Cross-sectional	Conditional, Global	"Imagine that an HIV-negative man has sex with a HIV-positive man who is being treated for his HIV infection and has an undetectable viral load. Please rate how risky you believe anal sex without a condom is when the HIV-negative partner is bottom (receptive)."	CAI% in past 6 months	Positive (for HIV+, HIV-/? participants) at two different time points (1997, 2005) No significance testing
Kalichman, 2002 [136]	HIV+ men, USA	Cross-sectional	Conditional, Global	"Imagine that an HIV-negative person has sex with an HIV-positive man who is not being treated for his HIV infection. Please rate how risky you believe anal sex without a condom is when the HIV-negative partner is receptive." Same question is repeated for 2 other scenarios: • HIV+ man on protease inhibitors • HIV+ man on protease inhibitors w/ undetectable viral load	CAI in past 3 months	Positive 2/3 measures were not statistically significant
Kesler, 2016 [133]	HIV- MSM Canada	Cross-sectional	Unconditional, Global	"What do you think your chances are that you will ever get HIV/AIDS?"	CAI in past 6 months with: 1. casual male partner	Negative 2/3 outcomes were not

					2. HIV+ regular male partner 3. -HIV? regular male partner	statistically significant
Khumasen, 2017 [144]	MSM Thailand	Cross-sectional	Unconditional, Global	"I feel that the chances are good that I can get AIDS." "I am afraid that I might contract AIDS." "I believe that I can be exposed to HIV infection if my sex partner is heterosexual." "I believe that I can get AIDS even if I am only having sex with one partner."	Condom use at last anal intercourse	Null Not statistically significant
MacKellar, 2007 [76]	Young MSM (ages 23-29) USA	Cross-sectional	Unconditional, Global	"Using this card, choose a number that best describes how likely it is that you will become HIV positive in your lifetime."	CAI with HIV? men in the past 6 months	Negative Statistically significant
MacKellar, 2005 [152]	Young MSM (ages 15-29) USA	Cross-sectional	Unconditional, Global	Phase 1 – "Which of the following describes how likely it is that you are infected with HIV today?" Phase 2 – see MacKellar, 2007	CAI with HIV? men in the past 6 months	Negative Statistically significant
Maughan-Brown, 2018 [77]	Black women South Africa	Longitudinal design (analysis is cross-sectional)	Unconditional, Global	"Do you think you have no risk, a small risk, a moderate risk or a great risk of getting the AIDS virus?"	Condom use frequency with their most recent partner	Negative Statistically significant for all participants (not significant for HIV- participants)

Mehrotra, 2009 [147]	Young Heterosexuals (ages 18-36) USA	Cross-sectional	Conditional, Global	"If a person always used condoms, how likely do you think it is that they would get HIV in the next year?" "If a person never used condoms with a main sexual partner, how likely do you think that they would get HIV in the next year?" "If a person never used condoms with a casual sexual partner, how likely do you think that they would get HIV in the next year?"	Condom use frequency with all partners in past 3 months	Positive Statistically significant for both main and casual partners
Napper, 2012 [131]	HIV- or HIV? adults USA	Cross-sectional	Unconditional, Global	Perceived Risk of HIV Infection Scale (PRHS) consists of 8 questions covering 3 domains of perceived risk: affective, cognitive, and salience Affective ?: "I worry about getting infected with HIV *(none of the time, rarely, …)*." Cognitive ?: "I think my chances of getting infected with HIV are: *(zero, almost zero, …)*" Salience ?: "Getting HIV is something I have: *(never thought about, rarely thought about, …)*	CAI frequency (retrospective assessment)	Negative Statistically significant
Reisen, 1999 [79]	College students	Cross-sectional	Conditional, Partner-specific	Cross-sectional: "How great a risk for transmission of HIV did you	Partner-specific outcomes	Cross-sectional: Null

	USA	and longitudinal		think that your partner posed for you?" (in the last 4 weeks) Longitudinal: Question changed to reflect the perceived likelihood the partner has HIV.	Cross-sectional: Condom use at last intercourse (in the last 4 weeks) Longitudinal: Condom use at last intercourse (from baseline to 4 weeks after)	Longitudinal: Positive (statistically significant)
Remien, 2005 [78]	HIV+ MSM USA	Cross-sectional	Conditional, Global	Participants are asked to indicate how risky specific activities are in terms of transmitting HIV to a man who is HIV- or HIV? when: 1. "Your viral load is undetectable and you fuck him without a condom and cum inside him." 2. "You're taking a protease inhibitor and you fuck him without a condom and cum inside him."	Insertive CAI with HIV- or HIV? partners in past 3 months	Positive Statistically significant for 1 measure
Tsui, 2012 [132]	Sexually active injection drug users China	Cross-sectional	Unconditional and conditional, Global	Unconditional questions: 1. "How likely would you contract HIV?" 2. "How likely would you contract HIV as compared to other peer IDU of your age?" Conditional questions: 1. "How likely would you contract HIV if you have unprotected sex with regular sex partners?"	Condom use frequency with any female partner in past 6 months Intention to use condoms consistently in next 6 months	Unconditional: Negative for 1 measure, null for other measure (both not statistically significant) Conditional: Positive for all 3 measures (all statistically significant)

				2. same as 1 except with non-regular partners 3. same as 1 except with female sex workers		
van der Velde, 1996 [149]	Heterosexual adults Netherlands	Longitudinal design (analysis is cross-sectional)	Unconditional and conditional, Global	Unconditional question: "How do you estimate the chance that you will become infected with the AIDS-virus in the next two years, because of your sexual behavior?" Conditional question: "How do you estimate the chance that you will be infected with the AIDS-virus in the next two years, if you would not use condoms?"	Previous behavior score (incorporates number of sex partners, sex position, condom use frequency, and partner type) in the past 4 months Behavioral intention to use condoms in the next 4 months (by sex position and partner type)	Previous behavior: Unconditional ? – Negative for both partner types (statistically significant) Conditional ? – Positive for both partner types (not statistically significant) Behavioral intention: Unconditional ? – Negative for prostitution partners (statistically significant) Positive for private partners (not statistically significant) Conditional ? – Positive for both partner types (statistically significant)

[A] Conditional questions attach certain behaviors/partner-level characteristics to the likelihood of HIV infection. A global question represents a universal measure of perceived risk. Partner-specific questions measure the perceived risk specific to each sex partner.

[B] A positive association indicates that as perceived risk increases (or decreases), condom use increases (or decreases). A negative association indicates that as perceived risk increases (or decreases), condom use decreases (or increases). Statistical significance is determined at $p < 0.05$.

APPENDIX D. AIM 3 QUANTITATIVE SURVEY

CASCADE PROJECT

Instructions for Interviewer

Administer this survey after receiving written informed consent from the participant. Enter the participant's unique study ID in the first page of the online survey.

1. Enter the participant ID here:*

_____

Variable name: **study_id**

*Required Question

Instructions to the Participant

This survey should take no more than 10 minutes to complete. Please answer all of the questions as accurately as possible. All of your answers on this survey will be reported in aggregate, meaning that your individual information will never be reported by itself or to people outside of the study staff. Your personal information will be stored on a secured network within a password protected database. The only thing linking your name to this information is a unique ID that we have provided you. If you have any questions about this survey, please let the interviewer know

---

Section 1. Demographics

This next section will ask you questions about your personal characteristics including your race, sexual identity, age, education, employment, and housing.

2. Enter your age here:*

_____

Variable name: **age**

*Required Question

Must be a number from 18-39

3. What is your racial/ethnic background? (select one only)*

( ) White/Caucasian
1

( ) Black/African-American
2

( ) Hispanic/Latino
3

( ) Asian/Pacific-Islander
4

( ) Mixed race/ethnicity
5

( ) Other - Write In (Required):
_____* 6

Variable name: **race, race_oth**

*Required Question

4. Do you think of yourself as: (select one only)*

( ) Heterosexual or "Straight"
1

( ) Homosexual or Gay
2

( ) Bisexual
3

( ) Other - Write In (Required):
_____* 4

Variable name: **sexident, sexident_oth**

*Required Question

Employment & Education

5. Are you currently employed (meaning you currently have a paid full-time or part-time job)?

( ) Yes 1
( ) No 0

Variable name: **employed**

if "yes" to Q5, go to Q6; if "no" to Q5 go to Q7

6. How long have you been continuously unemployed for? (in other words, when was the last time you had a paying job?)

( ) < 6 months ago 1
( ) 7-12 months ago 2
( ) > 1 year ago 3
( ) Never had a paid job before 4
( ) Don't Know 9

Variable name: **unemploy_time**

7. What is the highest level of education that you've completed?

( ) College, post graduate, or professional school 1
( ) Some college, associate's degree, and/or technical school 2
( ) High school or GED 3
( ) Some high school 4
( ) Less than high school 5
( ) Never attended school 6

Variable name: **educ**

Health Insurance

8. Do you currently have health insurance (this includes Medicare or Medicaid)?

( ) Yes 1
( ) No 0

Variable name: **insure**

if "yes" to Q8, go to Q9; if "no" to Q8 go to Q10

9. What kind of health insurance or coverage do you have? (select one only)

( ) Private health insurance or HMO
1
( ) Medicaid
2
( ) Medicare
3

( ) TRICARE (CHAMPUS)
4

( ) Veterans Administration Coverage
5

( ) Other - Write In: _____
6

( ) Don't Know
9

Variable name: **insure_type, insure_type_other**

after Q9 automatically go to Q11

10. If you don't have health insurance, how do you pay for your medical expenses (including prescription drugs)? (select all that apply)

[ ] Ryan White Program
1/0

[ ] Other - Write In: _____
1/0

Variable name: **noinsure_rw, noinsure_oth, noinsure_oth_spf**

Housing & Incarceration

11. Are you currently homeless (meaning you either live on the street, in a shelter, car, Single Room Occupancy (SRO) hotel, or temporarily staying with friends or relatives)?

( ) Yes 1

( ) No 0

Variable name: **homeless**

if "yes" to Q11, go to Q12; if "no" to Q11 go to Q13

12. How long have you been continuously homeless for? (in other words, when was the last time you had a stable place to live in?)

( ) < 6 months ago	1
( ) 7-12 months ago	2
( ) > 1 year ago	3
( ) Don't Know	9

Variable name: **homeless_time**

13. Have you been arrested in the past 12 months?

( ) Yes	1
( ) No	0

Variable name: **arrested**

Section 2. Risk Behaviors

This next section will ask you questions about your past sexual behaviors and substance use. This includes information about your sex partners, condom use, and whether you disclosed or revealed your HIV-status to your partner(s). Additional questions on your past drug use will also be asked.

Sexual Behaviors

14. Did you have sex with anyone in the past 6 months?*

( ) Yes	1
( ) No	0

Variable name: **sex_6m**

*Required Question

if "yes" to Q14, go to Q15; if "no" to Q14 go to Q23

Sex Partners

15. In the past 6 months, how many people have you had sex with? If you don't know the exact number, please provide your best estimate.

Enter number here:

_____

Variable name: **num_sexp_6m**

Must be a number from 1-1000

16. Please select the gender(s) of all of the individual(s) you had sex with in the past 6 months: (select all that apply)*

[ ] Male	1/0
[ ] Female	1/0
[ ] Transgender (male to female)	1/0
[ ] Transgender (female to male)	1/0
[ ] Other - Write In (Required): _____*	1/0
[ ] Don't Know	1/0

Variable name: **sexpg_male, sexpg_female, sexpg_mtf, sexpg_ftm, sexpg_oth, sexpg_oth_spf, sexpg_unk**

*Required Question

17. Of the partners you had sex with in the past 6 months, were any... (select all that apply)

[ ] Main partners (someone you feel committed to above all others - this is someone you might call your boyfriend/girlfriend, significant other, life partner, or husband/wife)
1/0

[ ] Casual partners (someone you do not feel committed to above all others)

1/0

Variable name: **main_part, casual_part**

Sexual Intercourse

18. In the past 6 months, what type of sex did you have with your partners? (select all that apply)

[ ] Vaginal Intercourse 1/0

[ ] Receptive Anal Intercourse (you were on the bottom, your partner inserted his penis into your anus) 1/0

[ ] Insertive Anal Intercourse (you were on top, you inserted your penis into your partner's anus) 1/0

[ ] Oral sex 1/0

Variable name: **vaginal_int, rai, iai, oral_sex**

Choice for "Vaginal Intercourse" is only shown for those who reported female, transgender (both MTF and FTM), other, or don't know for their sex partners in Q16.

Choice for "Receptive Anal Intercourse" is only shown for those who reported male, transgender (both MTF and FTM), other, or don't know for their sex partners in Q16.

if "yes" to vaginal intercourse, receptive anal intercourse, or insertive anal intercoruse, go to Q19, otherwise go to Q20

19. In the past 6 months, how often did you (and your partner) use a condom when having vaginal or anal intercourse?

If you used a condom only part of the time during sexual intercourse (meaning you might have put on the condom after you started having sexual intercourse or you took it off at any time during sexual intercourse), then you should treat that as not using a condom for the purposes of this survey.

Please select the category that best estimates your frequency of condom use:

( ) Me and my partner(s) always used a condom during sexual intercourse (used condom 100% of the time) 1

( ) Me and my partner(s) used a condom most of the time during sexual intercourse (used condom more than 50% the time) 2

( ) Me and my partner(s) used a condom some of the time during sexual intercourse (used condom less than 50% the time) 3

( ) Me and my partner(s) rarely used a condom during sexual intercourse (used condom less than 25% of the time) 4

( ) Me and my partner(s) never used a condom during sexual intercourse (used condom 0% of the time) 5

( ) Don't Know 9

Variable name: **uavi_freq**

20. In the past 6 months, were you ever high or drunk while having sex?

( ) Yes 1

( ) No 0

( ) Don't Know 9

Variable name: **sex_high**

HIV Status Disclosure

21. In the past 6 months, did you have sex with anyone whose status was....

	Yes	No
...HIV-positive	( )	( )
...HIV-negative	( )	( )
...HIV status unknown	( )	( )

1/0 – yes/no

Variable name: **hivpos_part, hivneg_part, hivunk_part**

22. Among the partner(s) you had sex with in the past 6 months, how often did you disclose (or reveal) your HIV-positive status to these partner(s) before you first had sex with them?

( ) Always: 100% (I always told my sex partner(s) about my HIV-positive status before I first had sex with them) 1

( ) Most of the time: >50% (I told over half of my sex partner(s) about my HIV-positive status before I first had sex with them) 2

( ) Sometimes: <50% (I told less than half of my sex partner(s) about my HIV-positive status before I first had sex with them) 3

( ) Rarely: <25% (I told less than a quarter of my sex partner(s) about my HIV-positive status before I first had sex with them) 4

( ) Never: 0% (I never told my sex partner(s) about my HIV-positive status before I first had sex with them) 5

( ) Don't Know 9

Variable name: **disclose_freq**

Substance Use

23. In the past 6 months, did you use any drugs other than those prescribed to you by a doctor?

Examples of drugs may include: crystal meth (tina, crank, ice), crack or powdered cocaine, downers (Valium, Ativan, or Xanax), painkillers (Oxycontin, Vicodin, Percocet), hallucinogens (LSD, mushrooms), MDMA (ecstasy, E, X), Special K (ketamine), GHB (G, liquid G), heroin, marijuana, or poppers (amyl nitrate)

( ) Yes 1
( ) No 0
( ) Don't Know 9

Variable name: **drugs_6m**

if "no" to Q23 go to Q26, otherwise go to Q24

24. In the past 6 months, did you inject any drugs that weren't prescribed to you by a doctor with a needle?

( ) Yes 1
( ) No 0
( ) Don't Know 9

Variable name: **inject**

if "no" to Q24 go to Q26, otherwise go to Q25

25. In the past 6 months, did other people use your needles, syringes, or other injection equipment (filters, water) after you used them to inject drugs?

( ) Yes 1
( ) No 0
( ) Don't Know 9

Variable name: **needle_share**

Section 3. HIV Diagnosis & Care

This next section will ask you questions about when you were first diagnosed with HIV, when you were first prescribed antiretroviral medications, and how often you take your medications.

HIV Diagnosis & Care

26. When were you first diagnosed with HIV (when were you first told that you were HIV-positive)? Please tell us the month and year.

Year:*

( ) Don't know
( ) 1985
( ) 1986
( ) 1987
( ) 1988
( ) 1989
( ) 1990
( ) 1991

( ) 1992
( ) 1993
( ) 1994
( ) 1995
( ) 1996
( ) 1997
( ) 1998
( ) 1999
( ) 2000
( ) 2001
( ) 2002
( ) 2003
( ) 2004
( ) 2005
( ) 2006
( ) 2007
( ) 2008
( ) 2009
( ) 2010
( ) 2011
( ) 2012
( ) 2013
( ) 2014
( ) 2015
( ) 2016
( ) 2017
( ) 2018

Variable name: **dx_yr**

*Required Question

Month:

( ) January
( ) February
( ) March
( ) April
( ) May
( ) June
( ) July
( ) August
( ) September
( ) October
( ) November
( ) December

Variable name: **dx_mo**

27. Have you ever taken any HIV medications (antiretroviral therapy, HAART - highly active antiretroviral therapy, combination therapy) since you were first diagnosed with HIV?*

( ) Yes 1
( ) No 0

Variable name: **arv_ever**

*Required Question

if "yes" to Q27 go to Q28, otherwise go to end of the survey

28. When did you first start taking medications to treat HIV? Please tell us the month and year.

Year:*

( ) Don't know
( ) 1985
( ) 1986

( ) 1987
( ) 1988
( ) 1989
( ) 1990
( ) 1991
( ) 1992
( ) 1993
( ) 1994
( ) 1995
( ) 1996
( ) 1997
( ) 1998
( ) 1999
( ) 2000
( ) 2001
( ) 2002
( ) 2003
( ) 2004
( ) 2005
( ) 2006
( ) 2007
( ) 2008
( ) 2009
( ) 2010
( ) 2011
( ) 2012
( ) 2013
( ) 2014
( ) 2015
( ) 2016
( ) 2017
( ) 2018

Variable name: **med_yr**

*Required Question

Month:

( ) January
( ) February
( ) March
( ) April
( ) May
( ) June
( ) July
( ) August
( ) September
( ) October
( ) November
( ) December

Variable name: **med_mo**

if "yes" to Q27 go to Q28, otherwise go to end of the survey

Date (mo/yr) or initial medication must occur after date (mo/yr) of HIV diagnosis – otherwise error message will be shown and participant will be prompted to correct the date(s)

29. Are you currently taking any HIV medications (antiretroviral therapy)?

( ) Yes 1
( ) No 0

Variable name: **current_arv**

if "yes" to Q29 go to Q30, otherwise go to end of the survey

30. In the past 7 days (1 week), how often did you skip taking your HIV medications?

( ) Never skipped, took all of my prescribed pills every day

( ) Skipped taking my medications 1 day

( ) Skipped taking my medications more than 1 day

( ) Don't Know

Variable name: **adhere**

Thank You!