Health Disparities among Adolescent Sexual Minority Males: Associations with Multilevel Stigma and Implications for Pre-Exposure Prophylaxis Uptake

by Hannah Yellin

B.A. in Psychology, May 2012, Macalester College
M.P.H in Epidemiology, August 2016, The George Washington University

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Monica Ruiz
Associate Professor of Prevention and Community Health

The Milken Institute School of Public Health of The George Washington University certifies that Hannah Yellin has passed the Final Examination for the degree of Doctor of Philosophy as of February 13, 2023. This is the final and approved form of the dissertation.

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Hannah Yellin

Dissertation Research Committee:

Monica Ruiz, Associate Professor of Prevention and Community Health, Dissertation Director

Carlos Rodríguez-Díaz, Associate Professor of Prevention and Community Health, Committee Member

David Huebner, Professor of Prevention and Community Health, Committee Member

Yan Wang, Associate Professor of Prevention and Community Health, Committee Member

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Dedication

This dissertation is dedicated to the participants in the HPTN 083 study at George Washington University.

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Abstract of Dissertation

Health Disparities among Adolescent Sexual Minority Males: Associations with Multilevel Stigma and Implications for Pre-exposure Prophylaxis Uptake

Background: Adolescent sexual minority males (ASMM) experience health disparities, including elevated rates of HIV, depression, and substance use. These health disparities have been characterized as a "syndemic" in that they co-occur, interact, and are produced by conditions of social inequality. This dissertation investigates two research questions: 1) How is HIV sexual risk behavior related to multilevel sexual stigma among ASMM, and 2) How do psychosocial health problems impact HIV pre-exposure prophylaxis (PrEP) uptake among ASMM?

Aims and Hypotheses: Chapter 2 examined the hypothesis that state-level structural stigma would be positively associated with HIV sexual risk behavior, with positive indirect effects via interpersonal stigma, individual stigma, and psychosocial health problems. We also investigated differences in these associations by stage of adolescent development, hypothesizing that associations would be stronger in later adolescence compared to earlier adolescence. Chapter 3 investigated whether psychosocial health problems moderate an Information-Motivation-Behavioral Skills (IMB) model of willingness and intention to use PrEP. We first hypothesized that PrEP-related information and motivation would have indirect associations with PrEP willingness and intention via PrEP-related behavioral skills. We then tested the hypothesis that the magnitude of these associations would be attenuated among ASMM with psychosocial health problems compared to ASMM without psychosocial health problems.

Methods: We performed a secondary analysis of cross-sectional baseline data from a randomized controlled trial testing the efficacy of an HIV prevention intervention

("SMART"), which enrolled ASMM ages 13-18 in the U.S. between 2018 and 2020. Chapter 2 also used publicly available demographic, public opinion, and policy data to construct a measure of state-level structural stigma. Structural equation modeling and multigroup methods were used for the statistical analyses.

Results: In Chapter 2, there were no significant direct or indirect associations between state-level structural stigma and HIV sexual risk behavior. There was, however, a series of significant direct associations between structural stigma and victimization, victimization and substance use, and substance use and HIV sexual risk behavior. Multigroup analysis revealed equivalent associations among the key variables in early, middle, and late adolescence. The exception was a direct association between victimization and HIV sexual risk behavior in early adolescence only. In Chapter 3, information and social motivation were indirectly associated with willingness and intention to use PrEP via behavioral skills. In contrast, personal motivation was directly associated with willingness and intention to use PrEP. Depression and problematic substance use did not moderate these associations.

Discussion: The findings presented in Chapter 2 provide preliminary evidence of links between structural stigma, victimization, substance use, and HIV sexual risk behavior among ASMM. As the corresponding indirect effect was not significant, these relationships should be further evaluated in future studies. Efforts to intervene on the pathway from sexual stigma to HIV sexual risk behavior among ASMM should be developmentally-appropriate and should target multiple levels of stigma to achieve the greatest impact. The findings presented in Chapter 3 show that, among ASMM, the IMB model is an accurate theory of willingness and intention to use PrEP, which are important

precursors of PrEP adoption. The IMB model of willingness and intention to use PrEP remains accurate in the presence of depressive symptoms and problematic substance use.

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Chapter 1: Introduction

In the United States (U.S.), sexual minority youth accounted for over 90% of new HIV diagnoses among male adolescents ages 13 to 19 in 2018 (Centers for Disease Control and Prevention, 2019). Sexual minority youth are also more likely than heterosexual youth to experience poor mental health and use high-risk substances (Centers for Disease Control and Prevention, 2020). Despite these health disparities, research rarely includes adolescent sexual minority males (ASMM) under the age of 18 (Mustanski, 2015). Conducting research with ASMM is important because psychosocial health problems emerge during adolescence, due at least in part to exposure to prejudicial environments during sexual identity development (Bruce & Harper, 2011; Mustanski et al., 2011; Stall et al., 2008). Furthermore, psychosocial health problems experienced in adolescence can also affect health outcomes, such as HIV risk, in adulthood (Córdova et al., 2018).

Chapter 1 of this dissertation provides a brief review of HIV, depression, and substance use prevalence and disparities among ASMM. It then outlines a theory in the literature that attempts to explain these disparities: the theory of syndemic production. Chapter 1 concludes with an overview of the research questions considered in this dissertation. Chapter 2 presents the first manuscript, entitled "Multilevel sexual stigma as a social determinant of health disparities among ASMM." Chapter 3 presents the second manuscript, entitled "The impact of psychosocial health problems on HIV pre-exposure prophylaxis uptake among ASMM." Finally, Chapter 4 summarizes key findings, strengths and limitations, and directions for future research.

HIV among ASMM in the U.S.

According to the Centers for Disease Control and Prevention (CDC)'s annual HIV Surveillance Report, there were 6,135 HIV diagnoses among individuals ages 13-24 in 2020, accounting for 20% of all new HIV diagnoses that year (Centers for Disease Control and Prevention, 2022). Less than 1% of these 6,135 infections were among adolescents ages 13-14, 5% were among adolescents ages 15-17, and 16% were among adolescents ages 18-19. While these estimates are not specific to ASMM, the CDC also reports that 82% of all HIV diagnoses among 13- to 24-year-olds in 2020 were attributed to male-to-male sexual contact. In a study that was specific to ASMM and recruited participants ages 13 to 18 from three U.S. cities in 2015, 6% of the sample had a positive HIV test (Balaji et al., 2018). HIV prevalence in this study was highest among Black participants, followed by Latino and White participants, a trend that tracks national racial and ethnic disparities. This study found a high prevalence of HIV sexual risk behaviors, including condomless anal sex with a male partner in the past year, more than three male sex partners in the past year, and sexual concurrency with at least one recent partner.

ASMM are not well-engaged in HIV prevention, with low rates of HIV testing, condom use, and PrEP use (Centers for Disease Control and Prevention, 2019). First, with regard to HIV testing, the CDC estimates that almost half of young people ages 13-24 who are living with HIV do not know their HIV status (Centers for Disease Control and Prevention, 2021). In one recent study of 699 SMM ages 13-18, only 23% of participants had ever had an HIV test (Mustanski, Moskowitz, Moran, Rendina, et al., 2020). Research suggests this is partly due to fear and to anticipated stigma from healthcare providers and family members (Cahill et al., 2021; C. B. Fisher et al., 2018).

ASMM are hesitant to ask for HIV testing if they are not out about their sexual identity or behavior (Cahill et al., 2021). ASMM who have not disclosed their sexual activity to their parents or guardians are less likely to test for HIV (Nelson et al., 2020) and may be afraid of being outed by using their parents' health insurance for HIV testing (Cahill et al., 2021). Few states have explicit confidentiality protections for adolescents insured through their parents or guardians, although many states explicitly allow minors to consent to HIV testing without parental permission (Guttmacher Institute, 2022; Nelson et al., 2020). Despite this, having a legal capacity to consent to HIV testing is not associated with increased HIV testing because ASMM may still believe parental permission is required even when this is not the case in their state (Nelson et al., 2020).

With regard to condom use, younger ASMM report fewer anal sex acts than their older counterparts but are more likely to have condomless anal sex (Swann, Newcomb, et al., 2019). ASMM are also less likely to use condoms than their heterosexual counterparts (Raifman et al., 2018). In a meta-analysis that pooled estimates from 16 studies of SMM ages 14 to 19, 50% of sexually active participants did not use a condom during their most recent sexual encounter (Valencia et al., 2018). In a qualitative study, ASMM reported positive attitudes towards condom use but identified numerous barriers, including concerns about accessibility and low condom use negotiation skills (Cahill et al., 2021). School-based HIV education is associated with increased odds of condom use among ASMM. However, ASMM are less likely to report receiving HIV education than heterosexual adolescents (Raifman et al., 2018). Raifman et al. (2018) argue that this may be due to a lack of sexual minority-inclusive material in school-based sex education.

Finally, PrEP uptake among ASMM has been slow since the U.S. Food and Drug Administration (FDA) first approved PrEP for adolescents in 2018. In a national cohort of 1,398 SMM ages 13-18 participating in an HIV prevention study, over half of the sample were identified as appropriate PrEP candidates, yet only 3% were currently taking PrEP (Moskowitz et al., 2021). In another large national sample of SMM ages 13-24, every one-year increase in age was associated with a 31% increase in the odds of current PrEP use versus never having used PrEP (Whitfield et al., 2020). ASMM cite fear of their family finding out about their sexual identity or behavior as a reason for not using PrEP (Cahill et al., 2021; Moskowitz et al., 2020). Additionally, adolescent healthcare providers may have limited knowledge of PrEP and low comfort with prescribing it (Cahill et al., 2021; Hosek & Henry-Reid, 2020; Huebner & Mustanski, 2020; Pina et al., 2021). A latent class analysis of SMM ages 15-24 found that participants who had both higher levels of sexual health communication with their providers and higher autonomy in sexual health decisions ("shared decision-making") were more likely to report past or current PrEP use compared to participants who either had high communication but low autonomy ("provider-led decision-making") or high autonomy but low communication ("patient-driven decision-making") (Valente et al., 2022). Participants in the shared decision-making class were significantly older than those in the provider-led and patient-driven decision-making classes.

In summary, ASMM face many barriers to engaging in HIV prevention behaviors that are unique to their developmental stage. These barriers include dependence on parents and providers for access to services and issues surrounding consent and

confidentiality. This further underscores the need to include ASMM in HIV prevention research.

Depression and Substance Use among ASMM

Prevalence

Adolescence is a critical period for the development of depression and substance use problems (Gray & Squeglia, 2018; Thapar et al., 2022). Population-based data from 2019 indicate that 54% of gay and bisexual male high school students reported feeling so sad or hopeless almost every day for two or more weeks in a row in the past year that they stopped doing some usual activities (Johns et al., 2020). In one study of 547 SMM ages 13-18 from three U.S. cities, 52% were considered to have "probable" depression and anxiety (Agnew-Brune et al., 2019). In a study that used Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) criteria to identify mental health diagnoses among 449 SMM ages 16-20, the most common lifetime and past-year diagnosis was major depressive episode, at 33% and 18%, respectively (Burns et al., 2015). The age at which participants typically experienced onset of a major depressive episode was between 13 and 16.

With regard to substance use, the same study of 449 SMM ages 16-20 found that 20% had a lifetime alcohol abuse or dependence diagnosis and 7% had a past-year alcohol abuse or dependence diagnosis, based on DSM-IV criteria (Burns et al., 2015). Median age of onset was 18, and only 20% of those with a lifetime alcohol abuse or dependence diagnosis reported that they had ever received treatment. In a community sample of 450 SMM ages 16-20 in Chicago, 64% reported lifetime polysubstance use and 53% reported past six-month polysubstance use, with the most common pattern being

alcohol plus marijuana use (Newcomb et al., 2014). Participants frequently reported initiation of cigarette, marijuana, and alcohol use before age 15. Use of stimulants, such as cocaine and methamphetamines, and club drugs, such as ecstasy and GHB, typically began later in adolescence. In a study conducted with 569 ASMM in three U.S. cities from 2014 to 2015, 16- to 18-year-olds were more likely than 13- to 15-year-olds to report binge drinking (26% vs. 10%) and non-injection drug use (21% vs. 7%) (Robbins et al., 2020). The most frequently reported drugs among 16- to 18-year-olds were benzodiazepines (e.g., Xanax), ecstasy, painkillers (e.g., OxyContin), poppers, and cocaine.

Disparities

Sexual orientation disparities in depression and substance use are widely documented (Marshal et al., 2008, 2011; Mustanski et al., 2014; Russell & Fish, 2016). Most of this research assesses mental health symptoms and patterns of substance use rather than clinical diagnoses of mental health and substance use disorders (Marshal et al., 2008; Russell & Fish, 2016). One meta-analysis found that the odds of depressive symptoms are approximately three times greater among sexual minority adolescents compared to heterosexual adolescents (Lucassen et al., 2017). In a national sample of high school students from 2019, sexual minority students were more likely than heterosexual students to report persistent feelings of sadness or hopelessness, seriously considering attempting suicide, making a suicide plan, and attempting suicide during the past year (Centers for Disease Control and Prevention, 2020). Moreover, in a population-based analysis of temporal trends from 1999 to 2017, a decline in depressed mood was

observed among heterosexual adolescents, while rates of depressed mood were unchanged among sexual minority adolescents (Bettis & Liu, 2019).

Similarly, a meta-analysis found that the odds of substance use were 190% higher on average among sexual minority adolescents compared to heterosexual adolescents (Marshal et al., 2008). In their analysis of the association between sexual orientation and use of specific substances, Marshal et al. (2008) reported the largest average effect sizes for cocaine, injection drug use, and "composites" (any illicit substances excluding alcohol and tobacco) and the smallest average effect sizes for heavy alcohol use and marijuana. In other words, sexual orientation disparities were larger for substances that are less commonly used by adolescents. In the same national sample of high school students from 2019 described above, sexual minority adolescents were more likely than heterosexual adolescents to report lifetime use of illicit drugs and misuse of prescription opioids (Centers for Disease Control and Prevention, 2020).

The Theory of Syndemic Production

The theory of syndemic production was developed to explain the existence of health disparities among SMM, including increased rates of HIV, depression, and substance use. The term "syndemic," or "synergistic epidemic," was first used by Singer (1994) to refer to a "set of closely interrelated endemic and epidemic conditions, all of which are strongly influenced by a broader set of political-economic and social factors" (Singer, 1994). Singer, a medical anthropologist, used ethnographic and survey research conducted in a Puerto Rican community in the Northeastern U.S. to argue that substance abuse, violence, and AIDS (the "SAVA" syndemic) were best understood not as concurrent yet independent epidemics, but as interrelated, mutually enhancing conditions

produced and sustained by poverty and social marginalization. In hypothesizing the SAVA syndemic, Singer sought to understand HIV in this setting as part of a broader health crisis at the intersection of urban poverty and socially-devalued ethnicity. In more recent writings, Singer and colleagues outline three criteria that define a syndemic in a population: 1) the clustering of two or more diseases or health conditions, 2) adverse interaction between those diseases or health conditions, and 3) large-scale social forces that produce disease clustering and interaction (Mendenhall & Singer, 2020; Singer et al., 2017). Syndemic theory is useful in part because of its focus on the social conditions that produce epidemics, which distinguishes it from other models of disease concentration and interaction (Wilson et al., 2014).

Stall et al. (2003, 2008) extended Singer's work to a new population. While Singer argued that syndemics result from both cultural marginalization and poverty together, Stall et al. (2008) argued that "cultural marginalization alone is sufficient to produce a syndemic among American MSM [men who have sex with men]." Stall's "theory of syndemic production" proposed a developmental trajectory underlying health disparities among SMM, where "the early onset of this cluster of psychosocial health problems suggests that some phenomenon that occurs during childhood and/or adolescence shapes experiences of health problems in adulthood" (Stall et al., 2008). Stall et al. (2008) argue that this phenomenon involves socially-produced harms and early masculine socialization stress experienced in childhood and early adolescence, as well as exposure to stressors associated with migration to large urban centers in early adulthood. According to this theory, these experiences contribute to the accumulation of psychosocial health problems, including substance use problems, depression, and HIV

sexual risk behavior, which in turn "snowball" into a syndemic and lead to the emergence of physical health problems, including HIV.

Stall's theory of syndemic production integrates Singer's syndemic theory with minority stress theory to support the argument that cultural marginalization alone is sufficient to produce a syndemic among SMM. In doing so, this theory shifts the emphasis of HIV prevention by considering the role of the social environment as opposed to focusing exclusively on behavioral risk factors. The core argument of minority stress theory is that health disparities among sexual minority populations are caused by exposure to excessive stress from having a stigmatized social position (Meyer, 2003). Minority stressors include experiences of discrimination and victimization, expectations of these events and associated vigilance, the internalization of negative societal attitudes, and concealment of one's sexual orientation. This continuum of minority stressors ranges from distal to proximal (Meyer, 2003; Pachankis, 2015). Minority stress is hypothesized to be: 1) unique, in that it is different from the general stressors among stigmatized and non-stigmatized populations alike, 2) chronic, in that it is related to pervasive and persistent social and cultural structures, and 3) socially-based, in that it arises from the social environment. As Stall et al. (2003) state, "the lifelong effects of social marginalization or stigma may work to create high occurrence of psychosocial health problems among urban MSM, problems that in turn function in an additive manner to raise levels of high-risk sexual behavior and thus HIV infection itself."

Stall et al. (2003) were the first to empirically show that experiencing a greater number of psychosocial health problems, including polydrug use, depression, childhood sexual abuse, and intimate partner violence, was positively associated with HIV sexual

risk behavior and HIV incidence among adult SMM. Individuals reporting all four of these problems had over three times greater odds of reporting condomless anal sex with a serodiscordant partner or a partner with unknown HIV status than individuals reporting none of these problems (Stall et al., 2003). Subsequent research further substantiated the positive association between co-occurring psychosocial health problems and HIV risk and incidence, demonstrated in both cross-sectional studies (Halkitis et al., 2013; Mustanski et al., 2007) and longitudinal studies (Córdova et al., 2018; Halkitis et al., 2015; Mimiaga et al., 2015; Mustanski et al., 2017).

It should be noted that there has been some debate in the literature regarding the use of the term "syndemic" to describe these findings. Studies that analyze counts of psychosocial health problems lack evidence of interaction, which is central to the original definition of a syndemic (Tsai & Burns, 2015). Singer et al. (2020) describe these findings as evidence of "adverse additive co-morbidities" rather than of a "true" syndemic (Singer et al., 2020). However, these studies do support the theory of syndemic production's hypothesis that psychosocial health problems frequently co-occur and that SMM with more co-occurring psychosocial health problems experience greater HIV risk (Tsai & Burns, 2015).

Overview of the Research Questions

The theory of syndemic production identifies social adversity in the form of minority stress experienced during adolescence as a cause of the elevated rates of HIV, depression, and substance use observed among SMM. This motivates the research question considered in Chapter 2: how is HIV sexual risk behavior related to multilevel sexual stigma among ASMM? Specifically, this chapter addresses the lack of research on

how sexual stigma at the structural-level influences HIV risk among ASMM. We investigate the relationship between state-level structural stigma and HIV sexual risk behavior among ASMM, explore interpersonal stigma, individual stigma, and psychosocial health problems as potential explanatory mechanisms, and examine differences in these associations by stage of adolescent development. This study contributes to a greater understanding of mechanisms that are theorized to produce health disparities among ASMM. This study also contributes to a greater understanding of the developmental hypotheses made by the theory of syndemic production by investigating differences in the conceptual model by stage of adolescent development.

Furthermore, the elevated rates of depression and substance use problems identified as syndemic among ASMM may have implications for their engagement in HIV prevention behaviors. As Stall et al. (2003) state, "the existence of syndemics may make it difficult for some MSM to respond to the messages of standard HIV prevention programs." This motivates the research question considered in Chapter 3: how do psychosocial health problems impact PrEP uptake among ASMM? Specifically, this chapter uses a prominent theory of health behavior, the Information-Motivation-Behavioral Skills (IMB) model, to investigate whether depressive symptoms and problematic substance use moderate the associations between PrEP-related information, motivation, behavioral skills, and both willingness and intention to use PrEP among ASMM. This study uses an innovative approach by investigating the impact of psychosocial health problems disproportionately experienced by ASMM on social cognitive processes that are believed to be important for PrEP uptake.

Chapter 2: Multilevel Sexual Stigma as a Social Determinant of Health Disparities Among Adolescent Sexual Minority Males

Introduction

Adolescent sexual minority males (ASMM) in the U.S. are disproportionately affected by HIV. ASMM accounted for over 90% of new HIV diagnoses among male adolescents ages 13 to 19 in 2018 (Centers for Disease Control and Prevention, 2019). ASMM also experience psychosocial health disparities, including elevated rates of depression, problematic substance use, and exposure to violence, which are interrelated and associated with HIV risk (Mustanski et al., 2017; Perry et al., 2019; Robbins et al., 2020). Psychosocial risk factors experienced in adolescence, including alcohol and drug use, mental distress, and victimization, can affect HIV sexual risk behaviors into adulthood (Córdova et al., 2018).

Internalizing mental health problems, problematic substance use, and experiences of violence or victimization have been characterized as a "psychosocial syndemic" among SMM (Mustanski et al., 2017). A syndemic is defined as two or more diseases or health problems that cluster within a population and interact to exacerbate adverse health outcomes. Syndemic theory also focuses on the social conditions, such as poverty, stigma, and stress, that are most likely to produce syndemics (Singer et al., 2017). According to Stall et al.'s (2008) theory of syndemic production, social marginalization produces interrelated epidemics of substance abuse, depression, and HIV among SMM (Stall et al., 2008). The theory of syndemic production incorporates concepts from minority stress theory, which argues that the health disparities experienced by sexual

minority populations are caused by exposure to excessive stress from having a stigmatized social position (Meyer, 2003).

Stigma, or the "co-occurrence of labeling, stereotyping, separation, status loss, and discrimination in a context in which power is exercised" (Hatzenbuehler et al., 2013), is therefore an important concept in both the theory of syndemic production and minority stress theory. In their review of stigma and minority stress as social determinants of health among sexual minority youth, Hatzenbuehler and Pachankis (2016) identify three levels of stigma: 1) individual stigma, including self-stigma (i.e., internalized homophobia), rejection sensitivity, and concealment; 2) interpersonal stigma, including prejudice and discrimination (both overt actions such as bias-based hate crimes and covert actions such as microaggressions); and 3) structural stigma, defined as the "societal-level conditions, cultural norms, and institutional policies that constrain the opportunities, resources, and wellbeing of the stigmatized" (Hatzenbuehler & Pachankis, 2016).

Previous research conducted among adults demonstrates links between interpersonal stigma, individual stigma, psychosocial health problems, and HIV sexual risk behavior. In a study of SMM living with HIV, sexual minority victimization and internalized homophobia were associated with an increased risk of psychosocial health problems (Herrick et al., 2013). Timmins et al. (2020) found that the relationship between victimization and psychosocial health problems, namely psychological distress, was explained by an indirect effect via internalized homophobia (Timmins et al., 2020). Furthermore, Herrick et al. (2014) found a positive association between early-life adversity, including sexual minority victimization and discrimination, and HIV sexual

risk behavior that was mediated by a count variable consisting of psychological distress, illicit substance use, and alcohol misuse (Herrick et al., 2014). Similarly, a study conducted with Black SMM found indirect effects of social stigma, including homophobic violence and discrimination, on situational sexual behaviors via substance use and depression (Leblanc et al., 2021). Empirical research from outside of the syndemic literature suggests mediation of the association between internalized homophobia and sexual risk behavior by depression (Michael & Soskolne, 2020).

Structural stigma has been understudied compared to individual and interpersonal stigma (Hatzenbuehler, 2016), though the theory of syndemic production and minority stress theory both include hypotheses about structural stigma. Stall et al. (2008) identify cultural norms and institutional policies that discriminate against SMM as contextual factors influencing syndemic production. Minority stress theory hypothesizes that stigmatizing social structures drive psychosocial health disparities among sexual minority populations (Pachankis, 2015). As Hatzenbuehler (2016) states:

> Influential psychological theories of stigma at the individual level, such as minority stress and stigma-induced identity threat, posit structural-level sources for stigma. However, tests of these theories rarely interrogate structural sources of stigma…. This represents an important lacuna, because empirical tests of most psychological theories of stigma are incomplete without explicit measurement of structural stigma (Hatzenbuehler, 2016).

Theory suggests that multiple levels of stigma are part of the same causal pathway, whereby structural stigma leads to interpersonal stigma, leading to individual stigma: “Societal norms and beliefs often translate into enacted stigma at the

interpersonal level…. Stigma at the interpersonal level can shape stigmatized individuals' cognitive, affective, and behavioral processes" (White Hughto et al., 2015). Structural forms of stigma are described in the literature as "generators" of individual stigma (Hatzenbuehler, 2016). Hatzenbuehler (2010) argues that social policies are linked to mental health disparities through various pathways, one of which is increased exposure to minority stressors:

> Given that many current social policies appear to marginalize LGB individuals and delegitimate [sic] their relationships, it seems reasonable to hypothesize that such policies may increase exposure to the status-based stressors identified in Meyer's [minority stress] theory. In turn, stress is a robust risk factor for mental health problems, including psychosocial distress and psychiatric morbidity (Hatzenbuehler, 2010).

This hypothesis is infrequently tested, though an emerging body of research supports the link between structural stigma and adverse health outcomes among sexual minority populations (Hatzenbuehler, 2016). Additionally, limited empirical evidence suggests a positive association between structural stigma and HIV risk and incidence among adult SMM (Hatzenbuehler et al., 2020; Oldenburg et al., 2015; Pachankis et al., 2015). However, the latter studies largely do not examine interpersonal and individual stigma or psychosocial health problems as explanatory mechanisms. For example, Oldenburg et al. (2015) found that structural stigma was associated with HIV sexual risk behavior, such that individuals living in states with lower levels of structural stigma were less likely to report condomless anal sex. The authors speculated that internalized

homophobia, i.e., individual stigma, may be an explanatory mechanism, but they did not test this hypothesis.

Furthermore, these studies either do not include ASMM or do not disaggregate results for ASMM. Only one study on HIV risk could be identified that focused on an adolescent population and included a measure of structural stigma (Miller et al., 2018). In this study, a combined measure of structural sexual stigma and gender minority stigma was not associated with lifetime engagement in HIV-risky sexual partnerships. However, almost half of the study sample identified as heterosexual, and psychosocial health problems were not considered in the analysis. It is, therefore, not known how sexual stigma at multiple levels, including structural stigma, influences HIV sexual risk behavior among ASMM. ASMM are not well represented in research in general, despite the early onset of health disparities among SMM and the developmental nature of Stall et al.'s (2008) theory of syndemic production. In their review of HIV in young SMM, Mustanski and co-authors (2011) acknowledge, "the inclusion of YMSM [young men who have sex with men] under the age of 18 is critical to understanding HIV risk among YMSM, as many risk factors (e.g., substance use, sexual behavior, etc.) emerge during the transition from adolescence to emerging adulthood" (Mustanski et al., 2011).

At least two developmental considerations may have implications for the current study, given that the relationships between multiple levels of sexual stigma, psychosocial health problems, and HIV sexual risk behavior may differ across stages of adolescent development. First, sexual identity development typically occurs during adolescence. Though the timing of developmental milestones varies, research has suggested that recognition of same-sex attraction occurs during early adolescence and the assumption of

a sexual identity label occurs in late adolescence (Morgan, 2013). This may impact the conceptual model presently under study because, for example, internalized homophobia is a proximal minority stressor related to one's self-identity.

Second, the theory of syndemic production uses a developmental framework that emphasizes early-life experiences to explain syndemic production among SMM and proposes that psychosocial health problems accumulate over time. Psychosocial health problems and HIV sexual risk behavior may be less prevalent and less strongly associated with each other in early adolescence compared to late adolescence. For example, in a meta-analysis that included over 120,000 participants, the relationship between substance use and sexual risk behavior was stronger in studies with older adolescents compared to studies with younger adolescents (Ritchwood et al., 2015). The authors concluded that this might be explained by lower levels of parental monitoring, affiliation with riskier peer groups, greater social pressure, and greater availability and acceptability of substance use among older adolescents compared to younger adolescents. No study has examined stage of adolescent development as a moderator of the relationships between stigma at any level, psychosocial health problems, and HIV sexual risk behavior.

In sum, the theoretical and empirical literature suggests links between structural, interpersonal, and individual stigma, psychosocial health problems, and HIV sexual risk behavior among ASMM. However, to the best of our knowledge, a model containing all these variables has yet to be tested. The primary goal of this study was to investigate associations between multilevel sexual stigma, psychosocial health problems, and HIV sexual risk behavior among ASMM. In doing so, this analysis is consistent with Singer's (1994) original conceptualization of syndemics, in which HIV is understood within the

context of social conditions, including discrimination and homophobia, in which it spreads.

The first aim of this study was to examine the associations between sexual stigma at the structural, interpersonal, and individual levels, psychosocial health problems, and HIV sexual risk behavior among ASMM (Figure 2.1). The hypothesis was that structural stigma would be positively associated with HIV sexual risk behavior, with indirect effects via interpersonal stigma, individual stigma, and psychosocial health problems. The second aim was to investigate differences in these associations by stage of adolescent development. The hypothesis was that the direct and indirect associations between structural stigma and HIV sexual risk behavior would be stronger in later stages of adolescent development compared to earlier stages of adolescent development.

Methods

Study Design

Cross-sectional baseline data from a randomized controlled trial testing the efficacy of an HIV prevention intervention ("SMART") were used to investigate the aims of this study. The SMART program consists of three stepped-care eHealth interventions to reduce condomless anal sex and increase condom self-efficacy, condom use intentions, and HIV testing among ASMM. Details of the study design and methodology have been published elsewhere (Mustanski, Moskowitz, Moran, Newcomb, et al., 2020).

Sample

The baseline sample for the SMART program consisted of 1,624 ASMM who were enrolled between April 2018 and July 2020. Participants who met the following criteria were eligible to enroll in the study: 1) assigned male sex at birth, 2) identified as a

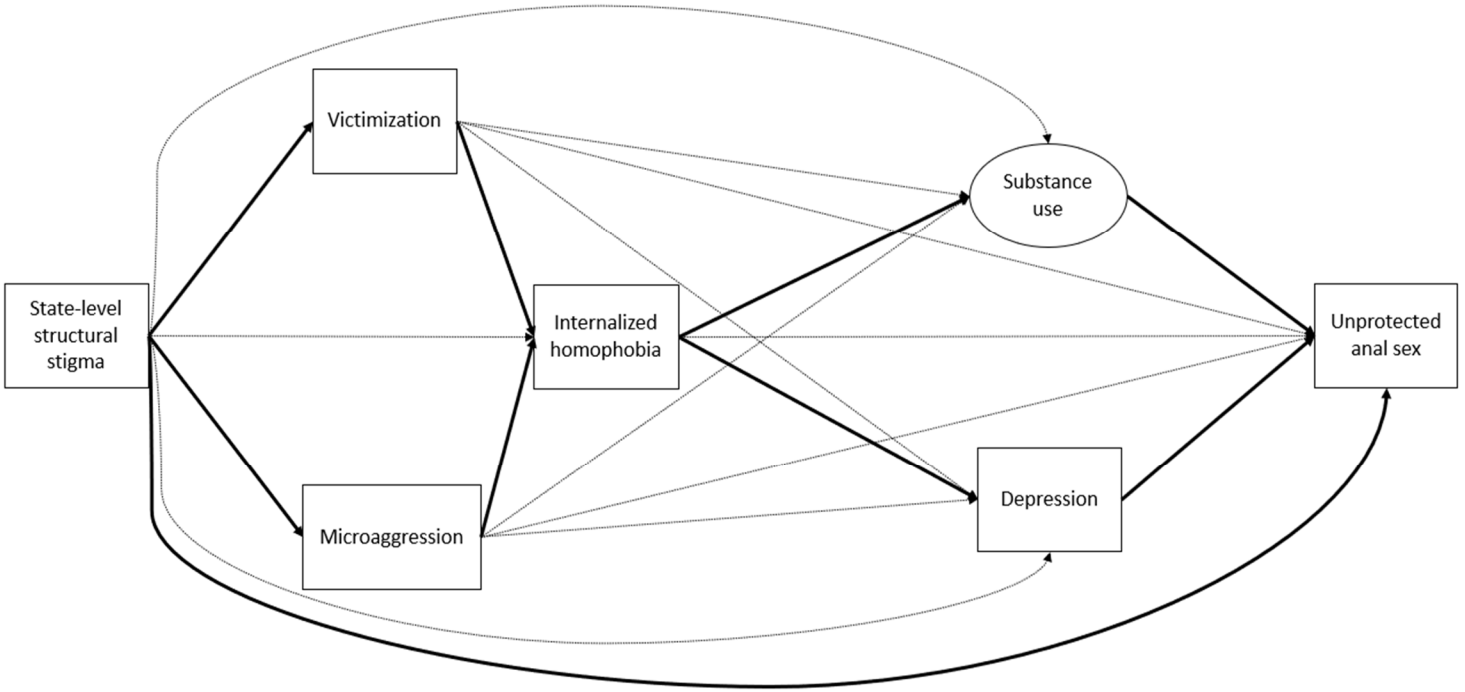

Figure 2.1. Hypothesized conceptual model of the direct and indirect associations between state-level structural stigma, interpersonal stigma (victimization and microaggression), individual stigma (internalized homophobia), psychosocial health problems (depression and substance use), and HIV sexual risk behavior (unprotected anal sex). All paths were hypothesized to be positive. All direct paths were tested. For clarity, the main paths of interest are bolded.

sexual minority or reported attraction to cisgender men, 3) reported an HIV-negative or unknown HIV status, 4) ever engaged in sexual contact with another person, defined as touching another person's genitals or engaging in oral, vaginal, or anal sex, 5) were age 13-18, 6) had access to or used the internet, 7) could read and speak English or Spanish at or above a sixth-grade level, and 8) lived in the U.S. including Puerto Rico, Guam, and American Samoa. Participants were recruited using paid advertising on social media and web-based engagement on geospatial dating apps and other social media. Community partners providing services to adolescents also supported recruitment by sharing information about the study on social media, websites, and mailing lists. The Northwestern University IRB granted a waiver of signed documentation of informed consent or assent and a waiver of parental permission for participants under 18. Participants answered four decisional capacity questions and were interviewed by study staff before enrolling in the study. Participants were compensated with $25 for completing the baseline survey.

Additional exclusions were made for the present study. As the key stigma measures could have tapped into the construct of stigma related to gender identity (Timmins et al., 2020), the analytic sample was restricted to cisgender ASMM to reduce possible measurement error. 98 participants, including participants who identified as female (n = 14), transgender (n = 8), gender non-conforming (n = 22), genderqueer (n = 13), or non-binary (n = 31), as well as participants who selected "not listed" when asked about their gender identity (n = 10), were excluded. This left 1,526 participants. Additionally, given the use of condomless anal sex as a component of the dependent variable, the analytic sample was further restricted to participants who reported ever

having anal sex. Otherwise, the comparison group for the dependent variable would have conflated participants who have had anal sex but not without a condom and participants who have never had anal sex. This is consistent with previous research on sexual behavior among adolescents (Okumu et al., 2019). This resulted in the exclusion of an additional 455 participants. Finally, some of the data sources used to create the structural stigma measure did not include U.S. territories or Washington, D.C. Therefore, the analysis was restricted to participants residing in the U.S. states. This resulted in the exclusion of an additional 33 participants, leaving 1,038 participants in the final analytic sample.

Data Collection

Participants completed an eligibility survey, provided consent, took the baseline survey, and were then able to access the first SMART intervention. Except for the data used to construct the structural stigma measure, all data used for this analysis are from the SMART baseline survey. The data were collected before exposure to the intervention.

Measures

Multilevel sexual stigma. The multilevel sexual stigma variables included state-level structural stigma, interpersonal stigma, and individual stigma.

Structural stigma. This measure was a state-level composite variable used in previous studies of structural stigma (Hatzenbuehler & McLaughlin, 2014; Oldenburg et al., 2015), including a study with an adolescent population (Charlton et al., 2019). It was composed of 1) the density of same-sex partner households, 2) the percentage of secondary schools with Gender-Sexuality Alliances (GSAs) or similar clubs, 3) state policies protecting sexual minority individuals, and 4) public opinion regarding policies

affecting sexual minority individuals. Construction and evaluation of this measure adhered as closely as possible to the methods reported in previous studies.

The first component was the density of same-sex partner households per state, measured as a relative ratio. Previous studies have used this as an indicator of whether same-sex couples are over- or under-represented in a given state relative to the national average (Hatzenbuehler & McLaughlin, 2014; Oldenburg et al., 2015). Whereas previous studies used data from the Census 2000 Summary File, data for this analysis were obtained from the Census Bureau's 2015-2019 American Community Survey (ACS), as this survey was conducted closer to the time of data collection for the SMART trial. The ACS's five-year estimates were used because they have smaller margins of error and increased statistical reliability for small population groups compared to its one-year estimates (U.S. Census Bureau, 2017). The number of married same-sex partner households and same-sex cohabiting couple households were summed for each state and divided by the total number of households per state to produce state-level ratios of same-sex partner households to total households. The state-level ratios were then averaged to produce an average national ratio of same-sex partner households to total households. The average national ratio was 0.0075. The state-level ratios were transformed into relative ratios by dividing them by the average national ratio, such that a state-level relative ratio of 2 indicates that same-sex partner households are twice as likely to be located in that state compared to the national average (Hatzenbuehler & McLaughlin, 2014). The states with the highest relative ratios were Delaware, Vermont, and Massachusetts (1.56, 1.51, and 1.49, respectively), while the states with the lowest

relative ratios were North Dakota, Mississippi, and Wyoming (0.52, 0.52, and 0.57, respectively).

The second component of the structural stigma composite variable was the percentage of secondary schools per state that had a GSA or similar club. Data were obtained from the CDC's 2014 School Health Profiles Report (Demissie et al., 2015). Previous studies reported that their data came from the Gay, Lesbian, and Straight Education Network (GLSEN), however this information could not be located from publicly available resources, and the GLSEN Research Institute did not respond to a request for data. However, the School Health Profiles Report has two advantages over data from GLSEN: it is not limited to GSAs that are registered with GLSEN, and because it uses random, systematic, equal-probability sampling methods, it offers a representative sample of public schools from grades 6 to 12. The Profiles Report from 2014 was selected because it had the least amount of missing data for the variable of interest, though it was still missing data for three states: Louisiana, New Mexico, and Utah. All three states were represented in Profiles Reports from other years. The estimates from all other available years were averaged to impute estimates for 2014. For example, data on GSAs in Utah schools were available for the years 2010, 2012, 2016, and 2018. The average across these years was used to obtain an estimate for 2014. A sensitivity analysis to compare the final structural stigma measure before and after imputing these missing data resulted in nearly identical scores. The percentage of secondary schools per state that had a GSA or similar club ranged from 12.5% (South Dakota) to 55.7% (Massachusetts).

The third component was state-level policies for the year 2018. Data were obtained from the Human Rights Campaign's 2018 State Equality Index (Warbelow et

al., 2018). The policies were: 1) policies that prohibited employment discrimination based on sexual orientation (0 = absence/1 = presence), 2) anti-bullying laws that provided specific protection based on sexual orientation (0 = absence/1 = presence), 3) laws that addressed hate or bias crimes based on sexual orientation (0 = absence/1 = presence), and 4) laws that permitted discrimination in adoption/foster placement (0 = presence/1 = absence). Previous studies used same-sex marriage as a fifth state-level policy, which was not included in this analysis given that data collection occurred after the 2015 Supreme Court decision establishing same-sex marriage rights throughout the United States. Each value was summed such that a score of 0 indicates states with the least protective laws and a score of 4 indicates states with the most protective laws. The resulting variable had a mean of 2.2 and ranged from 0 (9 states) to 4 (19 states).

The fourth and final component was a measure of societal attitudes and, as in previous studies that used the same measure of structural stigma, was obtained using data from Lax & Phillips (2009). These authors aggregated responses from 41 opinion polls conducted between 1999 and 2008 encompassing approximately 80,000 responses taken from random national samples on the following policy-specific areas: adoption by same-sex couples, hate crimes, health benefits, employment discrimination, housing discrimination, marriage, sexual behavior, and civil unions (Lax & Phillips, 2009). For example, the survey question for adoption was, “Do you think there should be adoption rights for gay and lesbian couples?” The authors reported state-level opinion estimates obtained by averaging the eight policy-specific opinions, with higher values indicating greater support for policies that protect sexual minority individuals. The mean opinion estimates had a grand mean of 55.3% and ranged from 38% (Utah) to 68%

(Massachusetts). Although these opinion polls predated the data collection period for the SMART trial, this is the same data source that has been used in multiple studies on structural stigma (Charlton et al., 2019; Hatzenbuehler & McLaughlin, 2014; Oldenburg et al., 2015; Pachankis et al., 2014) and therefore increases comparability with the literature. Oldenburg et al. (2015) argue that: 1) this measure of societal attitudes has more validity than an assessment taken at a single time point, and 2) even though the data are not recent, it can take time for changes in structural stigma to affect population health. In the current study, this item had significant positive correlations with the other three components of the structural stigma measure that used more recent data.

Following the same procedures reported by other studies that used this measure of structural stigma, several statistical tests were performed to determine whether these four items (density of same-sex couples, percentage of secondary schools with a GSA or similar club, public policies, and attitudes) could be combined into a single measure of structural stigma. Cronbach's alpha for the four component items was 0.92. Correlation coefficients between the four items were all significant and ranged from 0.67 (correlation between societal attitudes and the density of same-sex households) to 0.78 (correlation between the density of same-sex households and the percentage of secondary schools with a GSA or similar club). A principal components factor analysis of the four items resulted in the variables loading onto a single component (eigenvalue = 3.2), demonstrating construct validity. Because the principal components analysis indicated a single-factor solution and Cronbach's alpha suggested excellent internal consistency, the items were combined into a single structural stigma score.

Since each variable was measured on a different scale, a standardized z-score (mean = 0, SD = 1) was computed for each of the four items before combining them, as in previous studies. The z-scores were then summed to create the final measure of state-level structural stigma. Previous studies stopped the construction of the measure at this point, resulting in higher scores that indicated lower levels of structural stigma and lower scores that indicated higher levels of structural stigma. In the current study, the scoring was reversed for interpretability by multiplying the scores by -1. The final scores ranged from -6.45 (Massachusetts) to 5.30 (Mississippi), with an average of 0.14, where a higher score indicated higher levels of structural stigma (see Table S2.1 in the Appendix). The mean was 1.91 in the South, 1.51 in the Midwest, -0.44 in the West, and -4.01 in the Northeast. The states with the lowest and highest structural stigma were the same as those reported in a previous study that used the same measure (Oldenburg et al., 2015).

Interpersonal stigma. Interpersonal stigma was measured using two separate variables: self-reported experiences of victimization and microaggression. Experience of victimization in the past three months was measured using six items: "How many times have you been threatened with physical violence/had an object thrown at you/been punched, kicked, or beaten/been threatened with a knife, gun, or another weapon/has someone chased or followed you/has your property been damaged because you are, or were thought to be gay, bisexual, or transgender?" Items were rated on a 4-point scale ranging from 0 = "Never" to 3 = "Three times or more." Cronbach's alpha was 0.86. A composite score was calculated for each participant by summing their responses to the six items, with a higher score indicating more frequent victimization.

Experience of microaggression in the past three months was measured using two items that were adapted from existing scales (Swann et al., 2016; Woodford et al., 2015). Participants were asked to indicate how often they experienced the following: "Someone said 'you know how gay people are,'" and "Someone expressed a stereotype (example: 'gay men are so good at fashion')." Items were rated on a 5-point scale ranging from 1 = "Not at all" to 5 = "About every day." Cronbach's alpha was 0.70. A composite score was calculated for each participant by averaging their responses to the two items, with a higher score indicating more frequent microaggression.

Individual stigma. Internalized homophobia was used to operationalize individual stigma and was measured with eight items: "Sometimes I wish I were not gay or bisexual," "Sometimes I think that if I were straight, I would probably be happier," "I have tried to stop being attracted to men," "I feel that being gay or bisexual is a shortcoming for me," "Most of the time I am glad to be gay or bisexual" (reverse scored), "If there were a pill to make me straight I would take it," "Sometimes I wish I could become more sexually attracted to women," and "Sometimes I feel ashamed of my sexual orientation." Items were rated on a 4-point scale from 1 = "Strongly disagree" to 4 = "Strongly agree." Cronbach's alpha was 0.91. A composite score was calculated for each participant by averaging their responses to the eight items, with a higher score indicating higher levels of internalized homophobia.

Psychosocial health problems. Two measures of psychosocial health problems were used in this analysis: depressive symptoms and substance use. The latter consisted of alcohol use, marijuana use, and polydrug use.

Depressive symptoms. Depressive symptoms were measured in the SMART baseline survey with the Patient-Reported Outcomes Measurement Information System (PROMIS) Depression - Short Form 8b. This scale uses eight items to assess self-reported negative mood, views of self, social cognition, and decreased positive affect and engagement over the past week. For example, participants reported how often they felt worthless or hopeless in the past seven days using a 5-point scale ranging from 1 = "Never" to 5 = "Always." Cronbach's alpha was 0.94. A raw score was calculated by summing responses to each item and multiplying by eight, and then dividing by the number of items answered by the participant. The raw score was converted to a T-score, where a higher score indicates higher levels of depressive symptoms.

Alcohol use. Alcohol use in the past three months was measured in the SMART baseline survey with the three-item AUDIT-C scale. Participants who reported that they had used alcohol in the last three months were asked 1) "How often do you have a drink containing alcohol" (0 = "Never," 1 = "Monthly or less," 2 = "2-4 times a month," 3 = "2-3 times a week," 4 = "4 or more times a week), 2) "How many drinks containing alcohol do you have on a typical day when you are drinking?" (0 = "1 or 2," 1 = "3 or 4," 2 = "5 or 6," 3 = "7 to 9," 4 = "10 or more"), and 3) "How often do you have six or more drinks on one occasion?" (0 = "Never", 1 = "Less than monthly," 2 = "Monthly," 3 = "Weekly," 4 = "Daily or almost daily"). Participants who did not report lifetime use of alcohol were assigned a score of "0." Cronbach's alpha was 0.84. For this analysis, item responses were summed to create a final score for each participant, with higher scores indicating more alcohol use in the past three months. This scoring method is consistent with previous research (English et al., 2022; Rubinsky et al., 2013).

Marijuana use. Marijuana use was measured using a single item from the 10-item CUDIT scale. Participants who reported using marijuana in the last three months were asked to respond to the following item: "How often do you use marijuana?" (1 = "Monthly or less," 2 = "2-4 times a month," 3 = "2-3 times a week," 4 = "4 or more times a week"). Participants who did not report marijuana use in the last three months were assigned a score of "0."

Polydrug use. Drug use was assessed by asking participants to report lifetime and past three-month use of the following non-prescription drugs: synthetic marijuana, cocaine or crack, heroin, methamphetamines, GHB, ketamine, poppers, inhalants, hallucinogens or psychedelics, ecstasy, and other drugs. Polydrug use was coded "1" if a participant reported using two or more of these drugs in the past three months and "0" if a participant reported using none or only one of these drugs in the past three months. This measure excluded alcohol and marijuana use. Synthetic marijuana, or synthetic cannabinoids, was included in this measure while marijuana was not because it is used less commonly by adolescents, similar to the other drugs included in the polydrug use measure (in this sample, lifetime use of synthetic marijuana = 2.6% vs. lifetime use of marijuana = 53%). Tobacco use was not assessed in the baseline survey. Polydrug use is often used as a measure of substance use in studies of psychosocial syndemics among SMM (Chandler et al., 2020; Mimiaga et al., 2015; Mustanski et al., 2017).

HIV sexual risk behavior. Past three-month anal sex without the use of condoms or pre-exposure prophylaxis (PrEP) was analyzed as the binary dependent variable. Initially, lifetime unprotected anal sex with male partners was also considered as a dependent variable since sexual behavior among adolescents can be intermittent

(Huebner & Mustanski, 2020). However, at least 60% of participants in each developmental group reported anal sex in the past three months. Therefore, only results from the model using past three-month unprotected anal sex as the dependent variable are presented. Using a measure of recent behavior is more in line with condom use measurement in the HIV prevention literature (Fonner et al., 2014). Participants who reported having anal sex with male partners were asked to indicate with how many of those partners they had condomless sex. Participants were also asked if they had taken PrEP in the past three months. Unprotected anal sex was coded "1" if a participant reported condomless anal sex and no PrEP use in the past three months and "0" if a participant reported condomless anal sex and PrEP use in the past three months or no condomless anal sex in the past three months.

Stage of adolescent development. Participants were grouped into the following stages of adolescent development based on their age: early adolescence (ages 13-15), middle adolescence (ages 16-17), and late adolescence (age 18). These age ranges were selected to ensure a sufficient number of participants in each group while staying as close as possible to developmental stages as defined by the CDC.

Covariates. The following sociodemographics assessed by the SMART baseline survey were considered for inclusion as covariates in the analysis: age, race/ethnicity, sexual identity, employment status, urban/rural residence, student status, living with parent/caregiver, family receipt of public assistance, and perceived economic strain. Perceived economic strain was measured using the 8-item Responses to Stress Questionnaire, which asked participants to report how often they experienced economic strain in their entire life (e.g., "My parents didn't have enough money to pay the bills,"

"We didn't have enough money to go places I wanted to go") and was rated on a 4-point scale ranging from 0 = "Not at all" to 3 = "Almost every day." Scores for each stressor were summed to create a total economic strain score (Wadsworth & Compas, 2002). Cronbach's alpha in this sample was 0.93. Education level was not included because it was highly correlated with age. Family income was not measured in the baseline survey. State-level variables that were considered for inclusion as covariates were HIV prevalence per 100,000, median household income, and population density (Oldenburg et al., 2015; Pachankis et al., 2014). State-level HIV rates from 2018 were obtained from AIDSVu (*Tools & Resources*, 2022). Median household income and population density per state, also from 2018, were obtained from the U.S. Census.

Statistical Analysis

Preliminary analysis. Descriptive statistics and bivariate correlations stratified by developmental stage were calculated to summarize the sample. Distributional differences in the key variables by developmental stage were assessed using ANOVA and chi-square tests. Post-hoc testing with adjustment for multiple comparisons was performed for variables that differed significantly across the three groups in order to identify which pairs were significantly different. Post-hoc testing was performed using the Tukey-Kramer test for comparisons of means and Fisher's exact test with stepdown Bonferroni adjustment for comparisons of frequencies. Multicollinearity was assessed using a bivariate correlation matrix and PROC REG to determine whether the variables were within recommended ranges (correlations < 0.80, tolerance values > 0.10, and variance inflation < 10). Univariate and bivariate analyses were performed using SAS software version 9.4 (SAS Institute Inc., Cary, NC, USA).

Handling of missing data. Of the key variables, only the alcohol and marijuana use measures were missing data. They were both 99.9% complete (missing $n = 1$ and $n = 2$, respectively). Of the covariates, only urban/rural residence was missing data ($n = 7$). Logistic regression models predicting missingness for each variable with missing data using the key variables and covariates as predictors revealed no significant associations.

Primary analysis. Structural equation modeling (SEM) was used to investigate both aims in Mplus version 7.31 (Muthén & Muthén, 2012). For the first aim, the hypothesized pathways were tested in the aggregate sample (Figure 2.1). Direct paths were specified between structural stigma and psychosocial health problems and between structural stigma and HIV sexual risk behavior because other possible mechanisms link these variables, such as decreased financial and social resources, that were not part of the present study. Furthermore, structural stigma is hypothesized to impact health even without directly experiencing interpersonal stigma (Hatzenbuehler, 2010).

All measures were treated as manifest variables. The exception was substance use, which was a latent factor indexed by the three indicators (alcohol, marijuana, and polydrug use). Interpersonal stigma was initially tested as a latent factor indexed by victimization and microaggression, however, the factor loadings were not significant, and these two constructs were instead treated as separate manifest variables.

In the first step of the primary analysis, confirmatory factor analysis (CFA) was used to test the measurement model of the latent factor for substance use. Robust weighted least squares estimation (WLSMV) was used to estimate model parameters for the measurement model, which had one binary indicator (Brown, 2015). The WLSMV estimator is robust to missing data (Asparouhov & Muthén, 2010). To determine the scale

of the latent factors, the variance of the factors was constrained to one, and the indicator with the strongest loading was identified. The measurement models were then respecified to constrain the loading of that indicator to one.

Next, separate full SEM with measurement and structural models was used to test the hypothesized direct and indirect associations between the three levels of stigma, psychosocial health problems, and HIV sexual risk behavior. Because cross-sectional data lack temporal precedence, indirect effects rather than mediation per se were tested. Mediation necessarily implies "the transmission of changes from cause to mediator to outcome," while "the term 'indirect effect' may still apply if directionality assumptions in a cross-sectional study have a strong rationale" (Kline, 2015). Because of the binary dependent variable, model estimation was again performed using WLSMV. Participants living in the same state were likely to be more similar to each other than participants living in different states. The TYPE=COMPLEX command adjusted standard errors to account for clustering given the use of a state-level variable and the non-independence of observations within states. Victimization and microaggression were allowed to covary, as were depression and substance use.

The second aim was investigated using multigroup analysis. Before testing the structural model, measurement invariance testing was performed to determine whether the substance use measurement model was invariant across the three developmental groups. The CFA model was first analyzed separately in each of the three groups. Separate models were then estimated for each group but were analyzed simultaneously in the same model. This model was then used to test for configural invariance, which assumed only a similar factor structure and allowed the factor loadings and intercepts to

differ across groups. The metric model, which adds equality constraints to factor loadings, was not tested because one of the indicators was binary (Brown, 2015; Muthén & Muthén, 2012). Instead, the next step was to test the scalar model, which added equality constraints on all factor loadings, intercepts, and thresholds. A chi-square difference test was used to determine whether the equality constraints significantly degraded the model fit. This was done with the DIFFTEST command given the use of WLSMV estimation (Muthén & Muthén, 2012). Measurement invariance was supported with a p-value ≥ 0.05 for the difference test between the scalar model and the configural model, indicating that the equality constraints did not significantly degrade model fit.

After examining invariance of the substance use measurement model, multigroup analysis was used to evaluate differences in the structural paths across the three stages of adolescence. If there was no significant difference in the measurement model across groups, we held the measurement model invariant and tested for equivalence in the structural model. Two models were estimated: 1) a model that allowed structural paths to vary across groups, and 2) a model that constrained all paths to equality across groups. The DIFFTEST command was used to test whether the constraints significantly degraded the model. A p-value less than 0.05 indicated that the constrained model significantly worsened model fit. Subsequent model building started with the fully constrained model, where all structural paths were constrained to equality across groups. Modification indices were inspected to determine which paths should be freed, with one path freed at a time until the chi-square difference test was not statistically significant.

Model fitness was evaluated using the Bentler comparative fit index (CFI), root mean square error of approximation (RMSEA), and the Tucker-Lewis index (TLI). The

standardized root mean squared residual (SRMR) was not available with WLSMV estimation. A CFI and TLI $\geq$ 0.90 and an RMSEA $\leq$ 0.08 indicated good model fit. Mplus calculated 90% confidence intervals (CI) for the RMSEA to provide information about the precision of the estimate. A narrow 90% CI that included or was close to zero indicated good fit. The chi-square test for model fit is reported but was not used to assess fit because it is highly influenced by sample size (Brown, 2015; Hu & Bentler, 1998). Modification indices were inspected to inform model respecification if the model fit was poor. Respecification was performed if the modification indices were consistent with theory. Unadjusted and adjusted models were tested. Adjusted models included covariates that were associated with the dependent variable or intermediary variables in bivariate analysis at $p < 0.20$. Indirect effects were tested, with $p < 0.05$ indicating a significant indirect effect. Bootstrapped confidence intervals could not be obtained as they are not available in Mplus for models that use the TYPE=COMPLEX command.

Finally, two sets of sensitivity analyses were conducted. The first investigated whether adjusting for additional covariates that could not be included in the multigroup analysis changed the results. Two variables that were measured in the SMART baseline survey, student status and living with parent(s)/caregiver(s), were associated with the independent variable and/or intermediary variables at $p < 0.20$ but could not be included as covariates in the multigroup model due to little to no variability among participants in early or middle adolescence. Specifically, 100% of participants in early adolescence and 95% of participants in middle adolescence were students, and 90-91% of these participants reported living with their parent(s) or caregiver(s). Therefore, a separate model for participants in late adolescence was estimated to adjust for student status and

living with parent(s) or caregiver(s), in addition to the other covariates. Similarly, age could not be included as a covariate in the multigroup model due to a lack of variability among participants in late adolescence. A separate model for participants in early or middle adolescence was estimated to adjust for age, in addition to the other covariates.

The second set of sensitivity analyses accounted for the COVID-19 pandemic. Data collection for the SMART trial continued into 2020, with the last baseline survey completed on July 3, 2020. As many, if not all, of the key variables could theoretically be affected by the COVID-19 pandemic, sensitivity analyses were conducted to assess the impact of the pandemic on the results. Participants were categorized based on whether they had completed the SMART baseline survey before or on/after March 12, 2020, which corresponds to the first U.S. statewide school closure (hereafter referred to as the "pre-COVID-19 sample" and the "post-COVID-19 sample"). The pre-COVID-19 sample consisted of 873 (84%) participants, including 119 participants in early adolescence, 379 participants in middle adolescence, and 375 participants in late adolescence. The post-COVID-19 sample consisted of 165 (16%) participants, including 15 participants in early adolescence, 57 participants in middle adolescence, and 93 participants in late adolescence. T-tests and chi-square tests were used to compare variable distributions between the two samples, and the SEM analysis was repeated in the pre-COVID-19 sample only.

Results

Sample characteristics

The analytic sample consisted of 1,038 participants, including 134 (13%) participants in early adolescence, 436 (42%) participants in middle adolescence, and 468

(45%) participants in late adolescence. Sociodemographic characteristics are presented in Table 2.1. The sample was approximately 37% Hispanic/Latino, 12% non-Hispanic Black/African American, 35% non-Hispanic White, and 16% were another race or multiracial. Most participants identified as gay (71%), were either out to most people or out to everyone (70%), lived with their parents or caregivers (78%), were students (89%), were not employed (56%), and lived in urban areas (82%). Just over a third of participants (36%) reported that their family received public assistance. Participants predominantly lived in the South (39%), followed by the West (27%), Midwest (18%), and Northeast (17%). Most participants (63%) lived in states with below median structural stigma scores (Figure 2.2). Experiences of interpersonal stigma in the past three months were common, with 41% reporting at least one instance of victimization and 94% reporting microaggression at least a few times.

Table 2.1. Sociodemographic characteristics of ASMM (N=1038)

	Total n (%)	Early adolescence ages 13-15 (n = 134)	Middle adolescence ages 16-17 (n = 436)	Late adolescence age 18 (n = 468)
Race/ethnicity				
Black/African American	128 (12.3)	19 (14.2)	49 (11.2)	60 (12.8)
Latino	385 (37.1)	48 (35.8)	157 (36.0)	180 (38.5)
Other/multiracial	166 (16.0)	20 (14.9)	65 (14.9)	81 (17.3)
White	359 (34.6)	47 (35.1)	165 (37.8)	147 (31.4)
Region				
Midwest	183 (17.6)	25 (18.7)	77 (17.7)	81 (17.3)
Northeast	173 (16.7)	21 (15.7)	64 (14.7)	88 (18.8)
South	400 (38.5)	51 (38.1)	171 (39.2)	178 (38.0)
West	282 (27.2)	37 (27.6)	124 (28.4)	121 (25.9)
Sexual identity				
Bisexual	233 (22.5)	29 (21.6)	91 (20.9)	113 (24.2)
Gay	741 (71.4)	96 (71.6)	312 (71.6)	333 (71.2)
Other	64 (6.2)	9 (6.7)	33 (7.6)	22 (4.7)
Out to no one or few people	309 (29.8)	35 (26.1)	147 (33.7)	127 (27.1)
Urban residence	847 (81.6)	113 (84.3)	340 (78.0)	394 (84.2)

Employed	459 (44.2)	18 (13.4)	204 (46.8)	237 (50.6)
Family receives public assistance	377 (36.3)	61 (45.5)	157 (36.0)	159 (34.0)
Lives with parents	811 (78.1)	121 (90.3)	398 (91.3)	292 (62.4)
Current student	927 (89.3)	134 (100.0)	415 (95.2)	378 (80.8)
Anal sex in the past 3 months	701 (67.5)	81 (60.5)	263 (60.3)	357 (76.3)
Lifetime PrEP use	56 (5.4)	0 (0)	11 (2.52)	45 (9.62)

ASMM (adolescent sexual minority males), PrEP (pre-exposure prophylaxis).

Bivariate analysis

Descriptive statistics and bivariate correlations stratified by stage of adolescent development are shown in Table 2.2 and Table 2.3, respectively. Victimization, alcohol use, marijuana use, polydrug use, and unprotected anal sex differed significantly by stage of adolescent development. Post-hoc testing to examine pairwise comparisons revealed that levels of these variables tended to increase across development, with the exception of victimization, which decreased across development. Compared to participants in middle and late adolescence, participants in early adolescence reported experiencing more victimization (early M = 2.82, SD = 4.30; middle M = 1.87, SD = 3.39; late M = 1.49, SD = 2.96). The difference between middle and late stages was not significant. Participants in late adolescence had higher alcohol use scores than those in middle and early adolescence, and participants in middle adolescence had higher alcohol use scores than those in early adolescence (early M = 0.87, SD = 1.38; middle M = 1.41, SD = 1.95; late M = 2.16, SD = 2.40). Participants in late adolescence used marijuana more frequently than those in middle and early adolescence (early M = 0.75, SD = 1.09; middle M = 0.85, SD = 1.29; late M = 1.10, SD = 1.41). The difference between middle and early stages was not significant. A greater proportion of participants in late adolescence reported polydrug use compared to those in middle and early adolescence (early = 5%; middle = 7%; late = 13%). The difference between middle and early stages was not significant.

Finally, a greater proportion of participants in late adolescence reported unprotected anal sex in the last three months compared to those in middle adolescence (middle = 43%; late = 51%). There were no significant differences in state-level structural stigma, microaggression, internalized homophobia, or depression across stages of adolescent development.

Table 2.2. Key variable distributions stratified by stage of adolescent development (N=1038)

Variable	Total	Early adolescence (n = 134)	Middle adolescence (n = 436)	Late adolescence (n = 468)	Test statistic[a]
			Mean (SD)		
Structural stigma	-0.88 (2.97)	-0.93 (2.85)	-0.78 (2.95)	-0.96 (3.04)	0.43
Victimization	1.82 (3.36)	2.82 (4.30)[b]	1.87 (3.39)[c]	1.49 (2.96)[c]	8.42***
Microaggression	2.79 (1.08)	2.77 (1.10)	2.84 (1.11)	2.75 (1.04)	0.77
Internalized homophobia	2.10 (0.78)	1.96 (0.77)	2.13 (0.78)	2.12 (0.78)	2.69
Depression	57.79 (8.88)	59.14 (8.54)	57.66 (8.82)	57.53 (9.02)	1.81
Alcohol use	1.68 (2.16)	0.87 (1.38)[b]	1.41 (1.95)[b]	2.16 (2.40)[d]	25.36****
Marijuana use	0.95 (1.33)	0.75 (1.09)[b]	0.85 (1.29)[b]	1.10 (1.41)[c]	5.67**
			N (%)		
Polydrug use	97 (9.3)	7 (5.2)[b]	31 (7.1)[b]	59 (12.6)[c]	11.13**
Unprotected anal sex	480 (46.2)	57 (42.54)[bc]	186 (42.66)[b]	237 (50.64)[c]	6.63*

Early = ages 13-15; Middle = ages 16-17; Late = age 18. Unprotected anal sex = Condomless anal sex and no PrEP use.

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$; ****$p < 0.0001$.

[a] Global test statistics are ANOVA F-tests and chi-square tests.

[b-d] Pairwise differences from Tukey-Kramer post-hoc testing with adjustment for multiple comparisons. For each variable, groups with the same letter were not significantly different from each other; groups with different letters were significantly different from each other at $p < 0.05$.

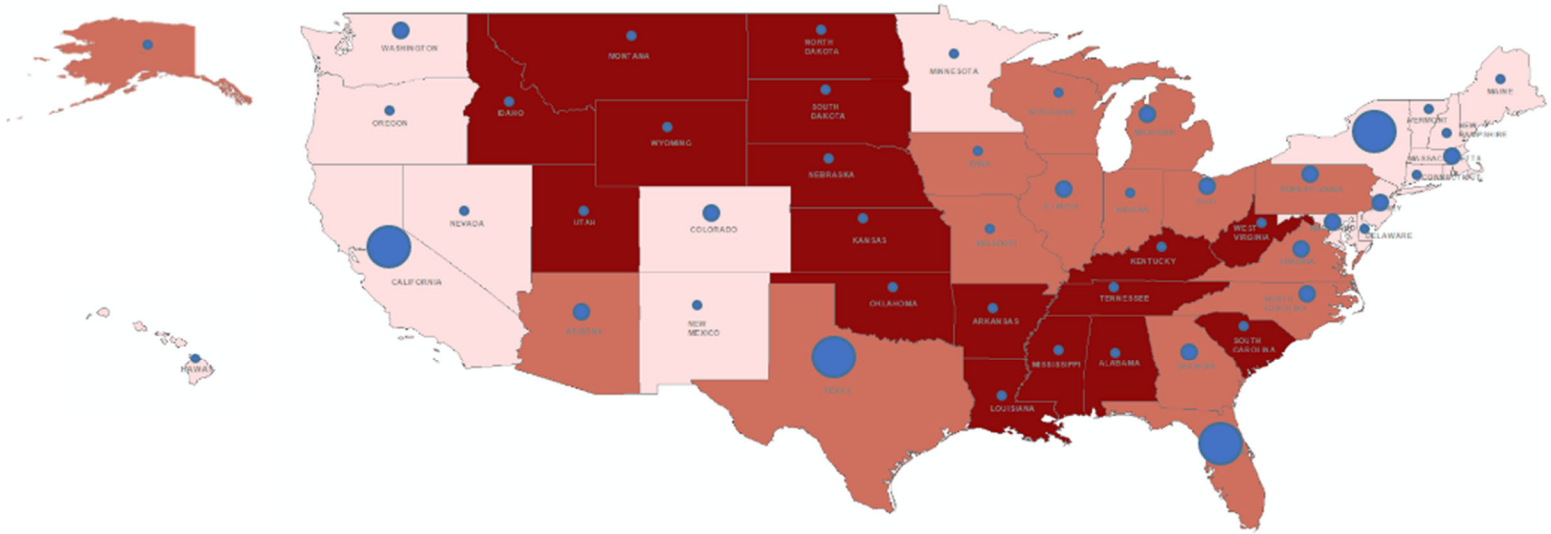

Figure 2.2. Choropleth map of state structural stigma scores. Lighter shades indicate lower structural stigma scores and darker shades indicate higher structural stigma scores. Circle sizes indicate distribution of participants in the sample. *Note*: Scores could not be calculated for U.S. territories or Washington, D.C. due to missing data.

Table 2.3. Bivariate correlations between key variables stratified by stage of adolescent development (N=1038)

	1	2	3	4	5	6	7	8	9
Early adolescence (n = 134)									
1. Structural stigma	--								
2. Victimization	-0.09	--							
3. Microaggression	-0.08	0.27**	--						
4. Internalized stigma	-0.13	0.17*	0.27**	--					
5. Depression	0.01	0.19*	0.23**	0.25**	--				
6. Alcohol use	0.11	0.03	0.10	0.03	0.02	--			
7. Marijuana use	0.10	0.13	0.06	0.11	0.07	0.44****	--		
8. Polydrug use	-0.01	0.14	-0.06	-0.06	0.09	0.34**	0.27**	--	
9. Unprotected anal sex	-0.15	0.22**	-0.00	-0.00	0.00	0.11	0.20*	0.21*	–
Middle adolescence (n = 436)									
1. Structural stigma	--								
2. Victimization	0.04	--							
3. Microaggression	0.01	0.27****	--						
4. Internalized stigma	-0.09	0.03	0.06	--					
5. Depression	-0.02	0.19****	0.20****	0.25****	--				
6. Alcohol use	-0.03	0.04	0.03	0.06	0.03	--			
7. Marijuana use	-0.04	0.05	-0.04	-0.06	-0.03	0.46****	--		
8. Polydrug use	-0.03	0.03	-0.03	-0.05	0.04	0.32****	0.35****	--	
9. Unprotected anal sex	-0.02	-0.06	-0.01	-0.06	-0.02	0.02	0.03	0.05	–
Late adolescence (n = 468)									
1. Structural stigma	--								
2. Victimization	0.09*	--							
3. Microaggression	0.06	0.26****	--						
4. Internalized stigma	0.04	0.05	0.14**	--					
5. Depression	0.04	0.25****	0.22****	0.38****	--				
6. Alcohol use	-0.06	0.12*	0.14**	0.04	0.09*	--			
7. Marijuana use	-0.12**	0.12**	0.01	0.08	0.10*	0.43****	--		

8. Polydrug use	-0.03	0.07	0.01	0.06	0.10*	0.30****	0.37****	--	
9. Unprotected anal sex	0.01	-0.01	0.02	0.01	0.02	0.06	0.04	0.05	–
Range	-5.30-6.45	0-18	1-5	1-4	38.2-81.3	0-10	0-4	0-1	0-1
Mean (SD)	-0.88 (2.97)	1.82 (3.36)	2.79 (1.08)	2.10 (0.78)	57.8 (8.89)	1.68 (2.16)	0.95 (1.33)	0.09 (0.29)	0.46 (0.50)
Alpha	0.92	0.86	0.70	0.91	0.94	0.84	–	–	–

Early = ages 13-15; Middle = ages 16-17; Late = age 18. Unprotected anal sex = condomless anal sex and no PrEP use.
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$; ****$p < 0.0001$.

Aim 1 results

Measurement model. With the variance of the latent factor fixed to 1, alcohol use had the strongest unstandardized factor loading. Therefore, the model was re-specified with the factor loading for this indicator fixed at 1. Because the model was just-identified, model fit statistics were not calculated, however all standardized factor loadings were significant and ranged from 0.66 (polydrug use) to 0.68 (marijuana use).

Structural model. To test the first aim, an unadjusted structural model was specified to examine the direct and indirect associations between structural stigma, victimization, microaggression, internalized homophobia, depression, problematic substance use, and unprotected anal sex. The unadjusted model had good overall fit ($\chi^2(12) = 17.59$, $p = 0.129$; RMSEA = 0.02 [90% CI 0.00-0.04]; CFI = 0.99, TLI = 0.96). Unadjusted direct and indirect effects for the primary hypotheses are displayed in Table 2.4. Structural stigma had no direct association with unprotected anal sex. There was only one significant indirect association between structural stigma and unprotected anal sex: a negative indirect effect from structural stigma to unprotected anal sex via substance use ($\beta = -0.013$, $p = 0.046$).

Additional direct effects from the unadjusted model are displayed in Table 2.5. Standardized results showed that microaggression had a direct and positive association with internalized homophobia ($\beta = 0.116$, $p = 0.000$) and with depression ($\beta = 0.131$, $p = 0.000$), victimization had a direct and positive association with depression ($\beta = 0.166$, $p = 0.000$), internalized homophobia had a direct and positive association with depression ($\beta = 0.278$, $p = 0.000$), and substance use had a direct and positive association with unprotected anal sex ($\beta = 0.161$, $p = 0.000$).

Given the significant direct effects between microaggression, internalized homophobia, and depression, we conducted a post-hoc test of the corresponding indirect effect and found a positive indirect effect from microaggression to depression via internalized homophobia ($\beta = 0.032$, $p = 0.000$) (Table 2.6).

The model was then adjusted for the three state-level covariates (HIV rate, population density, and median household income) and nine individual-level covariates (age, sexual identity, race/ethnicity, urban/rural residence, employment status, living with parent/caregiver, student status, family receipt of public assistance, and perceived economic strain). Seven cases with missing covariate data (i.e., rural/urban residence) were excluded. The adjusted model had good fit based on RMSEA = 0.02 [90% CI 0.00-0.03] and CFI = 0.97 but slightly less than acceptable based on TLI = 0.87. Paths between unprotected anal sex and all covariates except sexual identity and employment status were not significant and were deleted from the model. This resulted in good overall model fit ($\chi^2(46) = 56.60$, $p = 0.136$; RMSEA = 0.02 [90% CI 0.00, 0.03]; CFI = 0.97; TLI = 0.93). In the adjusted model, there was again no direct association between structural stigma and unprotected anal sex, and the indirect effect from structural stigma to unprotected anal sex via substance use was no longer significant (see Table 2.4). The standardized indirect effect from structural stigma to unprotected anal sex via victimization and substance use now approached significance ($\beta = 0.001$, $p = 0.086$).

Additional direct effects from the adjusted model are displayed in Table 2.5 and Figure 2.3. Standardized results showed that structural stigma had a direct and positive association with victimization ($\beta = 0.081$, $p = 0.047$), microaggression had a direct and positive association with internalized homophobia ($\beta = 0.131$, $p = 0.000$) and with

depression ($\beta = 0.116$, $p = 0.000$), victimization had a direct and positive association with depression ($\beta = 0.120$, $p = 0.000$) and with substance use ($\beta = 0.118$, $p = 0.003$), internalized homophobia had a direct and positive association with depression ($\beta = 0.265$, $p = 0.000$), and substance use had a direct and positive association with unprotected anal sex ($\beta = 0.163$, $p = 0.001$). The positive indirect effect from microaggression to depression via internalized homophobia remained significant ($\beta = 0.035$, $p = 0.000$).

Table 2.6 displays results from post-hoc testing of additional indirect effects. Given the significant direct associations between victimization, substance use, and unprotected anal sex, we conducted a post-hoc test of the indirect effect and found a significant positive indirect effect from victimization to unprotected anal sex via substance use ($\beta = 0.019$, $p = 0.011$). Given the significant direct associations between structural stigma, victimization, and depression, we also conducted a post-hoc test of this indirect effect. The indirect effect from structural stigma to depression via victimization approached significance ($\beta = 0.010$, $p = 0.061$). The indirect effect from structural stigma to substance use via victimization also approached significance ($\beta = 0.010$, $p = 0.067$).

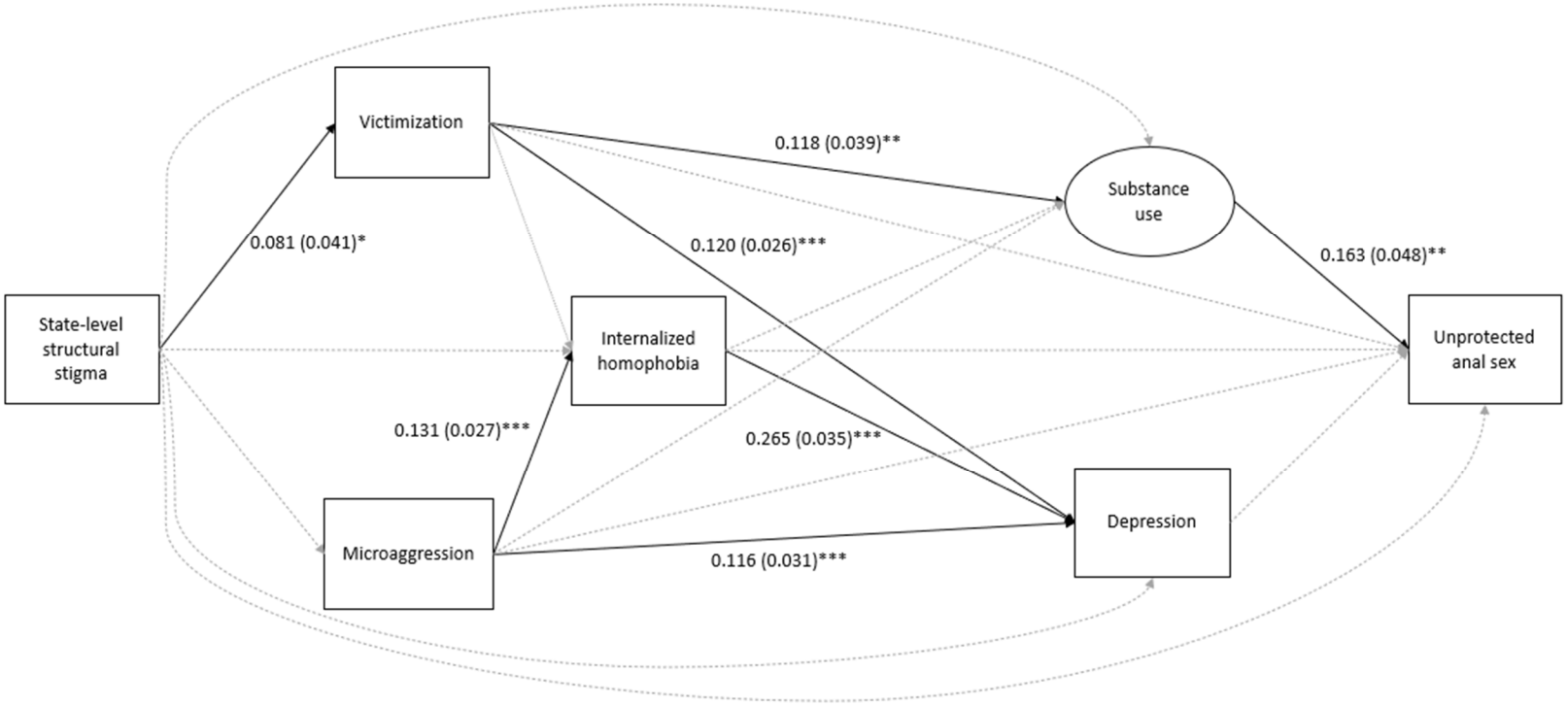

Figure 2.3. Structural equation model testing the associations between state-level structural stigma, interpersonal stigma (microaggression and victimization), individual stigma (internalized homophobia), psychosocial health problems (depression and substance use), and HIV sexual risk behavior (unprotected anal sex) among ASMM (N=1031). Significant standardized path coefficients are presented. Variable correlations and latent factor loadings are not shown. Adjusted for state-level covariates (HIV rate, population density, median household income) and individual-level covariates (age, sexual identity, race/ethnicity, urban/rural residence, living with parent/caregiver, student status, employment status, family receipt of public assistance, perceived economic strain), and accounting for clustering within each state. Model fit: $\chi^2(46) = 56.60$, $p = 0.136$; RMSEA = 0.02 (90% CI 0.00-0.03); CFI = 0.97; TLI = 0.93. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Table 2.4. Direct and indirect effects between structural stigma and past 3-month unprotected anal sex among ASMM (N=1038)

	Unadjusted model		Adjusted model[a]	
	b (SE)	*β* (SE)	*b* (SE)	*β* (SE)
Structural stigma				
Direct effect on unprotected anal sex	-0.006 (0.012)	-0.019 (0.035)	-0.020 (0.020)	-0.057 (0.059)
Indirect effect on unprotected anal sex via:				
Substance use	-0.004 (0.002)*	-0.013 (0.007)*	-0.005 (0.003)	-0.013 (0.010)
Depression	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.001)
Internalized homophobia	0.000 (0.001)	0.001 (0.002)	0.000 (0.001)	0.000 (0.000)
Microaggression	0.000 (0.000)	0.000 (0.001)	-0.001 (0.001)	-0.002 (0.003)
Victimization	0.000 (0.001)	-0.001 (0.002)	0.000 (0.001)	-0.001 (0.003)
Internalized homophobia → Substance use	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Internalized homophobia → Depression	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Microaggression → Substance use	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Microaggression → Depression	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Microaggression → Internalized homophobia	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Victimization → Substance use	0.000 (0.000)	0.001 (0.001)	0.001 (0.000)	0.002 (0.001)
Victimization → Depression	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Victimization → Internalized homophobia	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Microaggression → Internalized homophobia → Substance use	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Microaggression → Internalized homophobia → Depression	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Victimization → Internalized homophobia → Substance use	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Victimization → Internalized homophobia → Depression	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Total indirect effect on unprotected anal sex	-0.004 (0.002)	-0.013 (0.007)	-0.005 (0.003)	-0.015 (0.009)
Total effect on unprotected anal sex	-0.011 (0.011)	-0.031 (0.034)	-0.025 (0.020)	-0.073 (0.059)

ASMM (adolescent sexual minority males). *b* = unstandardized parameter estimate; SE = standard error; *β* = standardized parameter estimate.

[a] N = 1031 due to missing covariate data; adjusted for three state-level covariates (HIV rate, population density, and median household income) and nine individual-level covariates (age, sexual identity, race/ethnicity, urban/rural residence, employment status, living with parent/caregiver, student status, family receipt of public assistance, and perceived economic strain).

*$p < 0.05$.

Table 2.5. Additional direct effects from structural equation model of past 3-month unprotected anal sex among ASMM (N=1038)

	Unadjusted model		Adjusted model[a]	
	b (SE)	*β (SE)*	*b* (SE)	*β (SE)*
Direct effects				
State-level structural stigma → Microaggression	0.008 (0.010)	0.023 (0.028)	0.019 (0.016)	0.052 (0.043)
State-level structural stigma → Victimization	0.047 (0.030)	0.042 (0.027)	0.092 (0.041)*	0.081 (0.041)*
State-level structural stigma → Internalized homophobia	-0.010 (0.006)	-0.040 (0.023)	0.001 (0.011)	0.002 (0.041)
State-level structural stigma → Depression	0.033 (0.080)	0.011 (0.027)	0.021 (0.144)	0.007 (0.048)
State-level structural stigma → Substance use	-0.039 (0.021)	-0.081 (0.043)	-0.042 (0.030)	-0.083 (0.059)
State-level structural stigma → Unprotected anal sex	-0.006 (0.012)	-0.019 (0.035)	-0.020 (0.020)	-0.057 (0.059)
Microaggression → Internalized homophobia	0.084 (0.020)***	0.116 (0.027)***	0.094 (0.021)***	0.131 (0.027)***
Microaggression → Depression	1.080 (0.260)***	0.131 (0.032)***	0.956 (0.253)***	0.116 (0.031)***
Microaggression → Substance use	0.017 (0.070)	0.013 (0.053)	0.024 (0.063)	0.017 (0.044)
Microaggression → Unprotected anal sex	0.004 (0.041)	0.004 (0.032)	-0.031 (0.047)	-0.033 (0.050)
Victimization → Internalized homophobia	0.006 (0.006)	0.026 (0.027)	0.007 (0.007)	0.032 (0.028)
Victimization → Depression	0.438 (0.067)***	0.166 (0.026)***	0.314 (0.066)***	0.120 (0.026)***
Victimization → Substance use	0.037 (0.019)	0.088 (0.045)	0.053 (0.018)**	0.118 (0.039)**
Victimization → Unprotected anal sex	-0.005 (0.012)	-0.016 (0.039)	-0.005 (0.011)	-0.016 (0.037)
Internalized homophobia → Depression	3.164 (0.302)***	0.278 (0.031)***	3.004 (0.348)***	0.265 (0.035)***
Internalized homophobia → Substance use	0.105 (0.077)	0.057 (0.043)	0.058 (0.066)	0.030 (0.034)
Internalized homophobia → Unprotected anal sex	-0.029 (0.057)	-0.023 (0.044)	-0.001 (0.056)	-0.001 (0.043)
Depression → Unprotected anal sex	-0.001 (0.004)	-0.004 (0.035)	-0.002 (0.004)	-0.018 (0.038)
Substance use → Unprotected anal sex	0.113 (0.031)***	0.161 (0.045)***	0.109 (0.032)**	0.163 (0.048)**
Variable correlations				
Victimization <> Microaggression	0.958 (0.115)***	0.265 (0.027)***	0.823 (0.118)***	0.244 (0.029)***
Depression <> Substance use	0.655 (0.417)	0.056 (0.036)	0.943 (0.485)	0.084 (0.044)

ASMM (adolescent sexual minority males). *b* = unstandardized parameter estimate; SE = standard error; *β* = standardized parameter estimate
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.
[a] N = 1031 due to missing covariate data; adjusted for three state-level covariates (HIV rate, population density, and median household income) and nine individual-level covariates (age, sexual identity, race/ethnicity, urban/rural residence, employment status, living with parent/caregiver, student status, family receipt of public assistance, and perceived economic strain).

Table 2.6. Additional indirect effects from post-hoc testing

	Unadjusted model		Adjusted model[a]	
	b (SE)	*β* (SE)	*b* (SE)	*β* (SE)
Victimization				
Direct effect on unprotected anal sex	-0.005 (0.012)	-0.016 (0.039)	-0.005 (0.011)	-0.016 (0.037)
Indirect effect on unprotected anal sex via substance use	0.004 (0.002)	0.014 (0.008)	0.006 (0.002)*	0.019 (0.008)*
Total effect on unprotected anal sex	-0.001 (0.011)	-0.003 (0.038)	0.000 (0.012)	0.001 (0.039)
Microaggression				
Direct effect on depression	1.080 (0.260)***	0.131 (0.032)***	0.956 (0.253)***	0.116 (0.031)***
Indirect effect on depression via internalized homophobia	0.266 (0.074)***	0.032 (0.009)***	0.284 (0.080)***	0.035 (0.010)***
Total effect on depression	1.346 (0.270)***	0.163 (0.033)***	1.239 (0.253)***	0.151 (0.032)***
Structural stigma				
Direct effect on depression	0.033 (0.080)	0.011 (0.027)	0.021 (0.144)	0.007 (0.048)
Indirect effect on depression via victimization	–	–	0.029 (0.016)	0.010 (0.005)
Total effect on depression	–	–	0.077 (0.158)	0.026 (0.053)
Direct effect on substance use	-0.039 (0.021)	-0.081 (0.043)	-0.042 (0.030)	-0.083 (0.059)
Indirect effect on substance use via victimization	–	–	0.005 (0.003)	0.010 (0.005)
Total effect on substance use	–	–	-0.037 (0.032)	-0.072 (0.061)

ASMM (adolescent sexual minority males). *b* = unstandardized parameter estimate; SE = standard error; *β* = standardized parameter estimate.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.
[a] N = 1031 due to missing covariate data; adjusted for three state-level covariates (HIV rate, population density, and median household income) and nine individual-level covariates (age, sexual identity, race/ethnicity, urban/rural residence, employment status, living with parent/caregiver, student status, family receipt of public assistance, and perceived economic strain).

Aim 2 results

Measurement invariance testing. Measurement invariance testing by stage of adolescent development was performed for the latent factor of substance use. Although fit statistics for the one-factor model tested separately in each of the three developmental groups could not be calculated because the model was just-identified, all factor loadings were significant in each of the three groups (β = 0.58 to 0.70 across groups) and remained so when the models were analyzed simultaneously. For the configural invariance model using a multigroup approach, fit statistics were again not calculated because the model was just-identified. All factor loadings were significant in each of the three groups (β = 0.58 to 0.70 across groups). The scalar model had good fit ($\chi^2(6) = 5.14$, $p = 0.526$; RMSEA = 0.000, 90% CI = 0.00-0.06, CFI = 1.00, TLI = 1.00) and all factor loadings were significant in each of the three groups (β = 0.50 to 0.78 across groups). Constraining all factor loadings and intercepts/thresholds to be equal across groups did not significantly degrade the model ($\chi^2(6) = 5.14$, $p = 0.526$), thus supporting measurement invariance of the latent substance use factor.

Multigroup model. To test the second aim, multigroup analysis was used to examine the direct and indirect associations between structural stigma, victimization, microaggression, internalized homophobia, depression, substance use, and unprotected anal sex by stage of adolescent development. First, an unadjusted, unconstrained model was tested. This model had good overall fit ($\chi^2(42) = 50.57$, $p = 0.171$; RMSEA = 0.02 [90% CI 0.00-0.05]; CFI = 0.98; TLI = 0.95). Next, an unadjusted constrained model was tested, with all parameters forced to be equal across groups. The constrained model also had a good overall fit (RMSEA = 0.03 [90% CI = 0.01-0.04], CFI = 0.94, TLI = 0.92),

however, constraining all paths to equality across groups significantly degraded the model ($\chi^2(42) = 61.869$, $p = 0.024$).

Inspection of modification indices from the constrained model suggested that freeing the path from structural stigma to internalized homophobia would improve model fit. The chi-square test for difference testing remained significant ($\chi^2(40) = 55.923$, $p = 0.049$). Inspection of modification indices from the constrained model suggested that freeing the path from victimization to unprotected anal sex would improve model fit. The respecified model had a non-significant chi-square test for difference testing ($\chi^2(38) = 49.120$, $p = 0.107$), indicating that the remaining constraints did not significantly degrade model fit. The partially constrained model had good overall fit ($\chi^2(80) = 96.99$, $p = 0.100$; RMSEA = 0.03 [90% CI 0.00-0.04]; CFI = 0.96; TLI = 0.94). In the unadjusted partially constrained model, no significant direct or indirect effects were observed between structural stigma and unprotected anal sex in any group (Table 2.7).

Additional direct effects from the unadjusted multigroup model are displayed in Table 2.8. Standardized results showed that structural stigma had a direct and negative association with internalized homophobia among participants in middle adolescence ($\beta = -0.099$, $p = 0.004$), microaggression had direct and positive associations with internalized homophobia in all groups (early $\beta = 0.102$, $p = 0.004$; middle $\beta = 0.098$, $p = 0.002$; late $\beta = 0.090$; $p = 0.001$) and with depression in all groups (early $\beta = 0.155$, $p = 0.000$; middle $\beta = 0.145$, $p = 0.000$; late $\beta = 0.136$, $p = 0.000$), victimization had direct and positive associations with depression in all groups (early $\beta = 0.194$, $p = 0.000$; middle $\beta = 0.146$, $p = 0.000$; late $\beta = 0.133$, $p = 0.000$), with substance use in all groups (early $\beta = 0.182$, $p = 0.003$; middle $\beta = 0.110$, $p = 0.002$; late $\beta = 0.095$, $p = 0.003$), and with unprotected

anal sex among participants in early adolescence ($\beta = 0.261$, $p = 0.023$), internalized homophobia had direct and positive associations with depression in all groups (early $\beta = 0.274$, $p = 0.000$; middle $\beta = 0.267$, $p = 0.000$; late $\beta = 0.274$, $p = 0.000$), and substance use had a direct and positive association with unprotected anal sex in all groups (early $\beta = 0.115$, $p = 0.005$; middle $\beta = 0.148$, $p = 0.004$; late $\beta = 0.159$, $p = 0.002$).

There was a positive indirect association between microaggression and depression via internalized homophobia in all groups (early $\beta = 0.028$, $p = 0.005$; middle $\beta = 0.026$, $p = 0.003$; late $\beta = 0.025$, $p = 0.003$), and a positive indirect association between victimization and unprotected anal sex via substance use in all groups (early $\beta = 0.021$, $p = 0.035$; middle $\beta = 0.016$, $p = 0.035$; late $\beta = 0.015$, $p = 0.041$).

The partially constrained model was then adjusted for the three state-level covariates (HIV rate, population density, and median household income) and six of the individual-level covariates (sexual identity, race/ethnicity, urban/rural residence, employment status, family receipt of public assistance, and perceived economic strain). Seven cases with missing covariate data (i.e., rural/urban residence) were excluded: four participants in middle adolescence and three participants in late adolescence. The adjusted model had good fit ($\chi^2(155) = 176.30$, $p = 0.116$; RMSEA = 0.02 [90% CI = 0.00-0.03]; CFI = 0.95; TLI = 0.90). No direct or indirect effects were observed between structural stigma and unprotected anal sex in any group (Table 2.7).

Additional direct effects from the adjusted multigroup model are displayed in Table 2.8 and Figure 2.4. Standardized results showed that microaggression had direct and positive associations with internalized homophobia in all groups (early $\beta = 0.130$, $p = 0.000$; middle $\beta = 0.120$, $p = 0.000$; late $\beta = 0.112$, $p = 0.000$) and with depression in

all groups (early $\beta = 0.133$, $p = 0.000$; middle $\beta = 0.126$, $p = 0.000$; late $\beta = 0.116$, $p = 0.000$), victimization had direct and positive associations with depression in all groups (early $\beta = 0.147$, $p = 0.000$; middle $\beta = 0.118$, $p = 0.000$; late $\beta = 0.105$, $p = 0.000$), with substance use in all groups (early $\beta = 0.194$ $p = 0.002$; middle $\beta = 0.128$, $p = 0.000$; late $\beta = 0.106$, $p = 0.001$), and with unprotected anal sex among participants in early adolescence ($\beta = 0.284$, $p = 0.008$), internalized homophobia had direct and positive associations with depression in all groups (early $\beta = 0.241$, $p = 0.000$; middle $\beta = 0.247$, $p = 0.000$; late $\beta = 0.241$, $p = 0.000$), and substance use had direct and positive associations with unprotected anal sex in all groups (early $\beta = 0.109$, $p = 0.011$; middle $\beta = 0.141$, $p = 0.006$; late $\beta = 0.156$, $p = 0.005$).

There was a positive indirect association between microaggression and depression via internalized homophobia in all groups (early $\beta = 0.031$, $p = 0.000$; middle $\beta = 0.030$, $p = 0.000$; late $\beta = 0.027$, $p = 0.000$), and a positive indirect association between victimization and unprotected anal sex via substance use in all groups (early $\beta = 0.021$, $p = 0.035$; middle $\beta = 0.018$, $p = 0.033$; late $\beta = 0.017$, $p = 0.040$) (Table 2.9).

The pathway from structural stigma to victimization was freed in post-hoc exploration to further examine this parameter estimate in the multigroup model, given the significant direct association between structural stigma and victimization in the aggregate model, the significant bivariate correlation between these two variables among participants in late adolescence only, and the larger standardized coefficient for this pathway in late adolescence compared to the other groups in the multigroup analysis. While the parameter estimate was indeed stronger in late adolescence compared to

middle and early adolescence (β = 0.074 vs. 0.012 and 0.005, respectively), it was still non-significant (p = 0.368).

Sensitivity analyses. Adjusting for student status and living with parents/caregivers in late adolescence and adjusting for age in early and middle adolescence did not substantially change the direction or magnitude of the parameter estimates (Table S2.2 and Table S2.3 in the Appendix).

The COVID-19 pandemic had little impact on the results. Bivariate statistics for key variables stratified by pre-/post-COVID-19 status are shown in Table S2.4. Only internalized homophobia scores differed across groups, with significantly higher scores in the post-COVID-19 sample compared to the pre-COVID-19 sample (M = 2.24 vs. 2.08, respectively). Results did not substantially differ when the primary analysis was repeated in the pre-COVID-19 sample only. For the aggregate model, a comparison of adjusted unstandardized parameter estimates obtained from structural equation modeling in the full sample and the pre-COVID-19 sample is shown in Table S2.5. There were no direct or indirect associations between structural stigma and unprotected anal sex in the pre-COVID-19 sample. For the multigroup analysis, the adjusted unstandardized parameter estimates obtained from the full sample and the pre-COVID-19 sample are compared in Table S2.6. Again, there were no direct or indirect associations between structural stigma and unprotected anal sex in any of the groups.

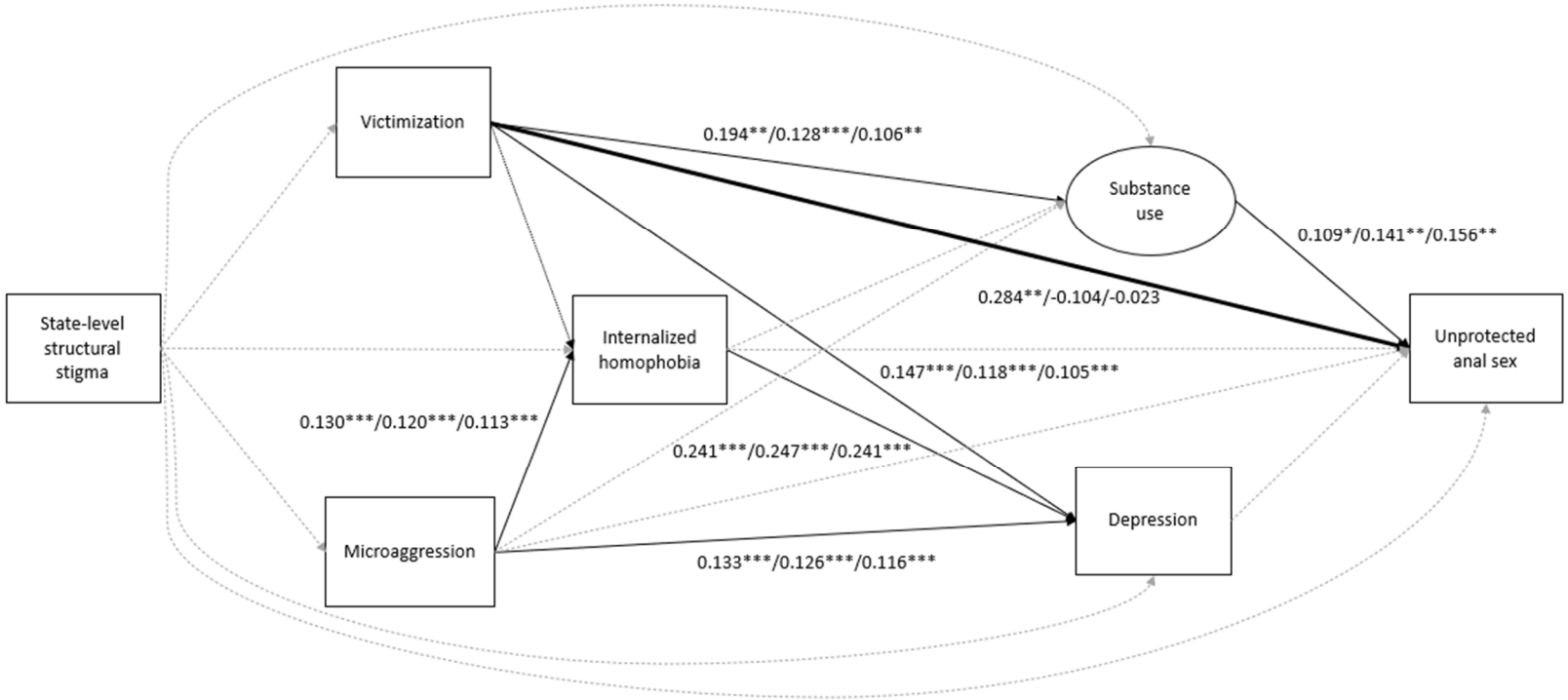

Figure 2.4. Multigroup analysis testing the associations between state-level structural stigma, interpersonal stigma (microaggression and victimization), individual stigma (internalized homophobia), psychosocial health problems (depression and substance use), and HIV sexual risk behavior (unprotected anal sex) among ASMM (N=1031). Significant standardized path coefficients are presented. Bolded path is estimated freely between groups. Non-bolded paths are constrained to equality across groups. Order of path coefficients between groups: early adolescence (age 13-15), middle adolescence (age 16-17), late adolescence (age 18). Standard errors, variable correlations and latent factor loadings are not shown. Adjusted for state-level covariates (HIV rate, population density, median household income) and individual-level covariates (sexual identity, race/ethnicity, urban/rural residence, employment status, family receipt of public assistance, perceived economic strain), and accounting for clustering within each state. Model fit: $\chi^2(155) = 176.30$, $p = 0.116$; RMSEA = 0.02 (90% CI 0.00-0.03); CFI = 0.95; TLI = 0.90. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Table 2.7. Direct and indirect effects between structural stigma and past 3-month unprotected anal sex from partially constrained multigroup structural equation model[a]

	Early adolescence (n = 134)				Middle adolescence (n = 436)				Late adolescence (n = 468)			
	Unadjusted		Adjusted[b]		Unadjusted		Adjusted[b]		Unadjusted		Adjusted[b]	
	b (SE)	*β* (SE)	*b* (SE)	*β* (SE)	*b* (SE)	*β* (SE)	*b* (SE)	*β* (SE)	*b* (SE)	*β* (SE)	*b* (SE)	*β* (SE)
Structural stigma												
Direct effect on UAS	-0.009 (0.011)	-0.024 (0.031)	-0.018 (0.018)	-0.050 (0.048)	-0.009 (0.011)	-0.025 (0.032)	-0.018 (0.018)	-0.053 (0.050)	-0.009 (0.011)	-0.026 (0.033)	-0.018 (0.018)	-0.055 (0.052)
Indirect effect on UAS via:												
SU	-0.003 (0.002)	-0.009 (0.006)	-0.003 (0.003)	-0.009 (0.009)	-0.003 (0.002)	-0.009 (0.007)	-0.003 (0.003)	-0.010 (0.010)	-0.003 (0.002)	-0.009 (0.007)	-0.003 (0.003)	-0.010 (0.010)
DP	0.000 (0.000)	0.000 (0.001)	0.000 (0.000)	0.000 (0.001)	0.000 (0.000)	0.000 (0.001)	0.000 (0.000)	0.000 (0.001)	0.000 (0.000)	0.000 (0.001)	0.000 (0.000)	0.000 (0.001)
IH	0.000 (0.002)	0.001 (0.005)	-0.001 (0.003)	-0.002 (0.007)	0.000 (0.001)	0.001 (0.004)	0.000 (0.001)	-0.001 (0.003)	0.000 (0.000)	0.000 (0.001)	0.000 (0.001)	0.001 (0.004)
MA	0.000 (0.000)	0.000 (0.001)	0.000 (0.001)	-0.001 (0.002)	0.000 (0.000)	0.000 (0.001)	0.000 (0.001)	-0.001 (0.002)	0.000 (0.000)	0.000 (0.001)	0.000 (0.001)	-0.001 (0.002)
VT	0.003 (0.003)	0.007 (0.008)	0.004 (0.005)	0.010 (0.013)	-0.001 (0.001)	-0.004 (0.004)	-0.002 (0.002)	-0.004 (0.006)	0.000 (0.001)	-0.001 (0.003)	0.000 (0.001)	-0.001 (0.003)
IH → SU	0.000 (0.000)	-0.001 (0.001)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	-0.001 (0.001)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
IH → DP	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)	0.000 (0.000)	0.000 (0.000)	0.000 (0.001)	0.000 (0.000)	0.000 (0.001)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.001)
MA → SU	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
MA → DP	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
MA → IH	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
VT → SU	0.000 (0.000)	0.001 (0.001)	0.000 (0.000)	0.001 (0.001)	0.000 (0.000)	0.001 (0.001)	0.000 (0.000)	0.001 (0.001)	0.000 (0.000)	0.001 (0.001)	0.000 (0.000)	0.001 (0.001)
VT → DP	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
VT → IH	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
MA → IH → SU	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
MA → IH → DP	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)

VT→ IH → SU	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
VT→ IH → DP	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Total indirect effect on UAS	0.000 (0.005)	0.000 (0.013)	0.000 (0.007)	-0.001 (0.020)	-0.004 (0.003)	-0.012 (0.009)	-0.005 (0.004)	-0.015 (0.011)	-0.003 (0.002)	-0.010 (0.007)	-0.004 (0.004)	-0.012 (0.011)
Total effect on UAS	-0.009 (0.012)	-0.024 (0.034)	-0.019 (0.019)	-0.051 (0.052)	-0.013 (0.011)	-0.037 (0.032)	-0.024 (0.017)	-0.069 (0.050)	-0.012 (0.011)	-0.036 (0.033)	-0.022 (0.017)	-0.067 (0.052)

ASMM (adolescent sexual minority males), DP (depression), IH (internalized homophobia), MA (microaggression), SU (substance use), UAS (unprotected anal sex), VT (victimization). *b* = unstandardized parameter estimate; SE = standard error; β = standardized parameter estimate.

[a] Paths between structural stigma and internalized homophobia and between victimization and unprotected anal sex were freely estimated between groups. All other paths were constrained to equality.

[b] N = 1031 due to missing covariate data; adjusted for three state-level covariates (HIV rate, population density, and median household income) and nine individual-level covariates (age, sexual identity, race/ethnicity, urban/rural residence, employment status, living with parent/caregiver, student status, family receipt of public assistance, and perceived economic strain).

Table 2.8. Additional direct effects from partially constrained multigroup structural equation model of past 3-month unprotected anal sex

	Early adolescence (n = 134)				Middle adolescence (n = 436)				Late adolescence (n = 468)			
	Unadjusted		Adjusted[b]		Unadjusted		Adjusted[b]		Unadjusted		Adjusted[b]	
	b (SE)	*β* (SE)	*b* (SE)	*β* (SE)	*b* (SE)	*β* (SE)	*b* (SE)	*β* (SE)	*b* (SE)	*β* (SE)	*b* (SE)	*β* (SE)
Direct effects												
SS → MA	0.01 (0.01)	0.02 (0.03)	0.01 (0.02)	0.04 (0.04)	0.01 (0.01)	0.02 (0.03)	0.01 (0.02)	0.04 (0.04)	0.01 (0.01)	0.02 (0.03)	0.01 (0.02)	0.04 (0.05)
SS → VT	0.04 (0.04)	0.03 (0.03)	0.05 (0.06)	0.03 (0.04)	0.04 (0.04)	0.04 (0.04)	0.05 (0.06)	0.04 (0.05)	0.04 (0.04)	0.04 (0.04)	0.05 (0.06)	0.05 (0.06)
SS → IH[a]	-0.03 (0.02)	-0.13 (0.08)	-0.05 (0.04)	-0.18 (0.15)	-0.03 (0.01)**	-0.10 (0.03)**	-0.02 (0.02)	-0.06 (0.06)	0.01 (0.01)	0.03 (0.04)	0.02 (0.02)	0.09 (0.06)
SS → DP	0.03 (0.00)	0.01 (0.03)	0.06 (0.11)	0.02 (0.04)	0.03 (0.09)	0.01 (0.03)	0.06 (0.11)	0.02 (0.04)	0.03 (0.09)	0.01 (0.03)	0.06 (0.11)	0.02 (0.04)
SS → SU	-0.03 (0.02)	-0.08 (0.05)	-0.03 (0.03)	-0.09 (0.08)	-0.03 (0.02)	-0.06 (0.04)	-0.03 (0.03)	-0.07 (0.06)	-0.03 (0.02)	-0.06 (0.04)	-0.03 (0.03)	-0.07 (0.06)
SS → UAS	-0.01 (0.01)	-0.02 (0.03)	-0.02 (0.02)	-0.05 (0.05)	-0.01 (0.01)	-0.03 (0.03)	-0.02 (0.02)	-0.05 (0.05)	-0.01 (0.01)	-0.03 (0.03)	-0.02 (0.02)	-0.06 (0.05)
MA → IH	0.07 (0.02)**	0.10 (0.04)**	0.09 (0.02)***	0.13 (0.03)***	0.07 (0.02)**	0.10 (0.03)**	0.09 (0.02)***	0.12 (0.03)***	0.07 (0.02)**	0.09 (0.03)**	0.09 (0.02)***	0.11 (0.03)***
MA → DP	1.17 (0.23)***	0.16 (0.03)***	1.00 (0.20)***	0.13 (0.03)***	1.17 (0.23)***	0.15 (0.03)***	1.00 (0.20)***	0.13 (0.03)***	1.17 (0.23)***	0.14 (0.03)***	1.00 (0.20)***	0.12 (0.02)***
MA → SU	0.05 (0.05)	0.06 (0.05)	0.00 (0.04)	0.01 (0.05)	0.05 (0.05)	0.04 (0.04)	0.00 (0.04)	0.00 (0.04)	0.05 (0.05)	0.04 (0.03)	0.00 (0.04)	0.00 (0.03)
MA → UAS	-0.01 (0.04)	0.01 (0.05)	-0.03 (0.04)	-0.03 (0.04)	-0.01 (0.04)	0.01 (0.04)	-0.03 (0.04)	-0.03 (0.04)	-0.01 (0.04)	0.01 (0.04)	-0.03 (0.04)	-0.03 (0.04)
VT → IH	0.01 (0.01)	0.06 (0.04)	0.01 (0.01)	0.04 (0.04)	0.01 (0.01)	0.05 (0.03)	0.01 (0.01)	0.03 (0.03)	0.01 (0.01)	0.04 (0.03)	0.01 (0.01)	0.03 (0.03)
VT → DP	0.39 (0.07)***	0.19 (0.04)***	0.31 (0.07)***	0.15 (0.04)***	0.39 (0.07)***	0.15 (0.03)***	0.31 (0.07)***	0.12 (0.03)***	0.39 (0.07)***	0.13 (0.03)***	0.31 (0.07)***	0.11 (0.02)***
VT → SU	0.05 (0.02)**	0.18 (0.06)**	0.05 (0.02)**	0.20 (0.06)**	0.05 (0.02)**	0.11 (0.04)**	0.05 (0.02)**	0.13 (0.04)***	0.05 (0.02)**	0.10 (0.03)**	0.05 (0.02)**	0.11 (0.03)**
VT → UAS[a]	0.06 (0.03)*	0.26 (0.12)*	0.07 (0.03)*	0.28 (0.11)**	-0.03 (0.02)	-0.10 (0.06)	-0.03 (0.02)	-0.10 (0.07)	-0.01 (0.02)	-0.03 (0.05)	-0.01 (0.02)	-0.02 (0.05)
IH → DP	3.09 (0.31)***	0.27 (0.04)***	2.72 (0.32)***	0.24 (0.04)***	3.09 (0.31)***	0.27 (0.03)***	2.72 (0.32)***	0.25 (0.03)***	3.09 (0.31)***	0.27 (0.03)***	2.72 (0.32)***	0.24 (0.03)***
IH → SU	0.07 (0.06)	0.05 (0.04)	-0.00 (0.05)	-0.00 (0.04)	0.07 (0.06)	0.04 (0.03)	-0.00 (0.05)	-0.00 (0.03)	0.07 (0.06)	0.04 (0.03)	-0.00 (0.05)	-0.00 (0.03)
IH → UAS	-0.01	-0.01	0.01	0.01	-0.01	-0.01	0.01	0.01	-0.01	-0.01	0.01	0.01

	(0.05)	(0.04)	(0.05)	(0.04)	(0.05)	(0.04)	(0.05)	(0.04)	(0.05)	(0.04)	(0.05)	(0.04)
DP → UAS	-0.00	-0.01	-0.00	-0.02	-0.00	-0.01	-0.00	-0.02	-0.00	-0.01	-0.00	-0.02
	(0.01)	(0.04)	(0.01)	(0.04)	(0.01)	(0.04)	(0.01)	(0.04)	(0.01)	(0.04)	(0.01)	(0.04)
SU → UAS	0.11	0.12	0.11	0.11	0.11	0.15	0.11	0.14	0.11	0.16	0.11	0.16
	(0.04)**	(0.04)	(0.04)**	(0.04)	(0.04)**	(0.05)**	(0.04)**	(0.05)**	(0.04)**	(0.05)**	(0.04)**	(0.06)**
Variable correlations												
VT <> MA	0.94	0.20	0.77	0.20	0.94	0.26	0.77	0.23	0.94	0.29	0.77	0.26
	(0.12)***	(0.03)***	(0.10)***	(0.04)***	(0.12)***	(0.03)***	(0.10)***	(0.03)***	(0.12)***	(0.03)***	(0.10)***	(0.03)***
DP <> SU	0.59	0.07	0.58	0.08	0.60	0.05	0.58	0.06	0.59	0.05	0.58	0.05
	(0.42)	(0.05)	(0.39)	(0.05)	(0.42)	(0.04)	(0.39)	(0.04)	(0.42)	(0.03)	(0.39)	(0.03)

ASMM (adolescent sexual minority males), DP (depression), IH (internalized homophobia), MA (microaggression), SS (structural stigma), SU (substance use), UAS (unprotected anal sex), VT (victimization). Early = ages 13-15; Middle = ages 16-17; Late = age 18. *b* = unstandardized parameter estimate; SE = standard error; β = standardized parameter estimate.

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

[a] Pathway was freely estimated across groups in unadjusted and adjusted models.

[b] N = 1031 due to missing covariate data; adjusted for state-level covariates (HIV rate, population density, median household income) and individual-level covariates (sexual identity, race/ethnicity, urban/rural residence, employment status, family receipt of public assistance, perceived economic strain).

Table 2.9. Additional indirect effects from partially constrained adjusted multigroup model (N=1031)

	Early adolescence (n = 134)		Middle adolescence (n = 432)		Late adolescence (n = 465)	
	b (SE)	*β* (SE)	*b* (SE)	*β* (SE)	*b* (SE)	*β* (SE)
Victimization						
Direct effect on unprotected anal sex	0.07 (0.03)*	0.28 (0.11)**	-0.03 (0.02)	-0.10 (0.07)	-0.01 (0.02)	-0.02 (0.05)
Indirect effect on unprotected anal sex via substance use	0.01 (0.00)*	0.02 (0.01)*	0.01 (0.00)*	0.02 (0.01)*	0.01 (0.00)*	0.02 (0.01)*
Total effect	0.08 (0.03)*	0.30 (0.11)**	-0.3 (0.02)	-0.09 (0.07)	-0.00 (0.02)	-0.01 (0.05)
Microaggression						
Direct effect on depression	1.00 (0.20)***	0.13 (0.03)***	1.00 (0.20)***	0.13 (0.03)***	1.00 (0.20)***	0.12 (0.02)***
Indirect effect on depression via internalized homophobia	0.24 (0.06)***	0.03 (0.01)***	0.24 (0.06)***	0.03 (0.01)***	0.24 (0.06)***	0.03 (0.01)***
Total effect	1.23 (0.21)***	0.17 (0.03)***	1.23 (0.21)***	0.16 (0.03)***	1.23 (0.21)***	0.14 (0.03)***

ASMM (adolescent sexual minority males). *b* = unstandardized parameter estimate; SE = standard error; *β* = standardized parameter estimate.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.
Adjusted for state-level covariates (HIV rate, population density, median household income) and individual-level covariates (sexual identity, race/ethnicity, urban/rural residence, employment status, family receipt of public assistance, perceived economic strain).

Discussion

This study was the first to examine sexual stigma at the structural-level and HIV sexual risk behavior among ASMM. Using a multilevel stigma framework, it was also one of the first to investigate possible mechanisms linking structural stigma to HIV sexual risk behavior. We did not find any significant direct or indirect associations between state-level structural stigma and HIV sexual risk behavior, as has been reported in previous studies among adult SMM (Hatzenbuehler et al., 2020; Oldenburg et al., 2015). We did, however, find preliminary evidence of a link between state-level structural stigma and HIV sexual risk behavior via interpersonal stigma, individual stigma, and psychosocial health problems. Specifically, a series of significant direct effects in the aggregate model provided new evidence of a potential pathway linking structural stigma to HIV sexual risk behavior via sexual minority victimization and substance use. As expected, these associations were all positive. Participants living in states with higher structural stigma were more likely to report experiences of sexual minority victimization. Participants who experienced more victimization reported more substance use, and those who reported more substance use were more likely to report unprotected anal sex. It should be noted that while each of these direct effects was significant, the indirect effect for the full pathway only approached significance. This could be due to the small magnitude of the association between structural stigma and victimization in the aggregate model.

Further, we examined developmental differences in the direct and indirect associations between structural stigma and HIV sexual risk behavior among ASMM. Although structural stigma was significantly associated with victimization in the

aggregate model, it was not significantly associated with victimization in the analysis that examined developmental stage as a potential moderator, even after allowing this path to be freely estimated in a post-hoc analysis. Bivariate analyses and post-hoc examination of the freely estimated paths signaled a possible relationship between these two variables among participants in late adolescence. Stratifying the sample by developmental stage may have limited the study's statistical power to find a significant association in this group, especially since the parameter estimate in the aggregate sample was very small. Studies with larger sample sizes or longitudinal data should further investigate whether the association between structural stigma and sexual minority victimization changes across adolescence. It is possible that ASMM in earlier developmental stages are more likely to be shielded from state-level structural stigma and its effects by their parents and communities. Structural stigma at the city- and school-levels may be more important for these adolescents. As ASMM transition into young adulthood and gain independence, state-level structural stigma may become more salient. These hypotheses should be investigated in future studies. For example, multilevel modeling methods could be used to examine whether city-level structural stigma moderates the association between state-level structural stigma and HIV sexual risk behavior. A recent study conducted among adult SMM reported cross-level interaction effects of state- and city-level structural stigma on concealment motivation, a proximal minority stressor (Lattanner et al., 2021). Another approach could be to treat migration between more or less stigmatizing environments as a natural experiment, such as when ASMM leave home for college. However, collecting data before and after such changes poses a challenge to studies of structural stigma that use a quasi-experimental approach (Hatzenbuehler, 2016).

In all of our models, we found evidence of an indirect effect of sexual minority victimization on HIV sexual risk behavior via substance use. This is consistent with previous research showing associations between sexual minority victimization and substance use among adolescents (Cordoba et al., 2021; Scheer et al., 2021; Swann, Forscher, et al., 2019), between sexual minority victimization and sexual risk behavior among adolescents (Bragard et al., 2021), and mediation of the relationship between sexual minority victimization and sexual risk behavior by substance use (Dermody et al., 2020). Our study extends these findings by showing that the indirect effect of victimization on HIV sexual risk behavior via substance use was relatively stable from early adolescence (ages 13-15) to late adolescence (age 18), suggesting the need for early and sustained interventions to prevent sexual minority victimization.

However, while the association between victimization and unprotected anal sex was fully accounted for by substance use in middle and late adolescence, the association between victimization and unprotected anal sex was only partially accounted for by substance use in early adolescence. In this group, a significant direct association between victimization and unprotected anal sex remained even after accounting for substance use. As in previous studies (Birkett et al., 2015; Swann, Forscher, et al., 2019), we found that victimization decreased across adolescence. The greater prevalence of victimization in early adolescence, combined with lower levels of substance use in early adolescence, may explain our finding that substance use only partially explained the relationship between victimization and unprotected anal sex in this group. Because substances are less accessible to younger adolescents and substance use is less acceptable in this developmental group, the association between victimization and unprotected anal sex in

early adolescence may be explained by other factors, such as rejection sensitivity, low condom use self-efficacy (Wang & Pachankis, 2016), or perceived lack of interpersonal power in sexual relationships (Bragard et al., 2021). This finding suggests that not only is early intervention needed, but that such interventions should be developmentally-tailored, as the mechanisms linking victimization to HIV risk may differ across development. Further research is needed to examine explanatory mechanisms in early adolescence.

Sexual minority victimization and microaggression, two types of sexual stigma at the interpersonal level, had different relationships with structural stigma in this study. Structural stigma was associated with victimization in the aggregate model, as discussed above, but it was not associated with microaggression in any of the models. Participants living in more protective states were just as likely to report experiencing microaggression as were participants living in less protective states. A large majority of participants reported recent experiences of microaggression. While overt victimization may be marginally more common in states with higher structural stigma, covert forms of interpersonal stigma are more pervasive because they reflect implicit bias (Nadal et al., 2016). To the best of our knowledge, this was the first study to examine structural stigma in relation to victimization and microaggression. Our results indicate that different interventions may be required to address these forms of interpersonal stigma, and that state-level policies alone may be insufficient. Addressing both victimization and microaggression is important given our finding that they are each independently associated with negative health consequences among ASMM.

Victimization and microaggression also had different relationships with internalized homophobia. While previous studies have found positive associations

between victimization and internalized homophobia (Puckett et al., 2018; Swann, Forscher, et al., 2019), victimization was not associated with internalized homophobia in any of our models. Microaggression was associated with internalized homophobia, and through internalized homophobia was indirectly associated with depression. Newcomb & Mustanski (2010) point out that the increased visibility of sexual minorities and the decrease in discrimination and prejudicial attitudes in the U.S. over time may have changed the nature and effects of internalized homophobia. Our study used data collected between 2018 and 2020, while previous studies that linked victimization and internalized homophobia have used somewhat older data (Puckett et al., 2018). Thus, though our results do not imply causality, they are suggestive of possible changes in the causes of internalized homophobia as well. Moreover, that both victimization and microaggression were uniquely associated with depression in the same model provides further evidence that microaggression is associated with mental health problems even beyond the effects of overt victimization (Swann et al., 2016). Overall, these results lend support to the conclusion that with "increased tolerance and visibility, homophobic behavior has become more subtle in nature but no less detrimental in its effects on mental health" (Newcomb & Mustanski, 2010).

There are both practical and methodological implications of the finding that victimization and microaggression operated differently in the models. One practical implication is that integrated interventions to reduce health disparities among ASMM should focus on different types of interpersonal stigma to achieve the greatest health impact. Regarding methodological implications, most studies on interpersonal stigma among sexual minority youth focus on overt interpersonal stigma, namely peer

victimization and bullying (Hatzenbuehler & Pachankis, 2016). Few studies incorporate multiple forms of interpersonal stigma (Gower et al., 2021), and those that do may operationalize them as indicators of a single latent factor (Timmins et al., 2020). Similarly, substance use and depression, two forms of psychosocial health problems which operated differently in our models, are often combined into a single count variable or latent factor, and sometimes combined with victimization and internalized homophobia, particularly in the syndemics literature. The methodological approach used in many studies of combining various forms of interpersonal stigma and psychosocial health problems, while demonstrating shared variance between these constructs, may obscure important differences in their causes and effects.

No association, either direct or indirect, was found between internalized homophobia and unprotected anal sex in any developmental group. While this finding is contrary to our hypotheses, it is consistent with a meta-analysis that identified year of data collection as a moderator of the relationship between internalized homophobia and sexual risk behavior, such that the correlation between these variables has weakened over time (Newcomb & Mustanski, 2011). The authors provide several possible explanations for this finding, including advances in HIV treatment, decreases in HIV stigma, and reduced variability in internalized homophobia due to greater societal acceptance of sexual minority populations over time.

Additionally, we found a non-significant association between depression and unprotected anal sex that was equivalent across all developmental stages. This may be explained by our use of a dichotomous measure of unprotected anal sex, which furthermore did not distinguish between sexual positioning practices. A previous study

conducted with adult SMM found an association between depression and condomless anal sex when the outcome was operationalized as a count variable, and the only dichotomous measure of condomless anal sex to be associated with depression was condomless receptive anal sex, specifically (Millar et al., 2017). In our study, a dichotomous variable was selected because operationalizing unprotected anal sex as a count resulted in a zero-inflated variable with little variability, and we did not account for sexual positioning because this information was only available in the data source at the partner-level. It may also be the case that the association between depression and condom use is curvilinear, such that those with moderate levels of depression are more likely to have condomless sex than those with low or high levels of depression (Babowitch et al., 2018). However, previous research conducted among ASMM has failed to support this hypothesis (Agnew-Brune et al., 2019).

This study had several limitations. The use of cross-sectional data limits causal inference due to a lack of temporal precedence. However, given that structural stigma was an objective measure, it is expected that this variable could only be exogenous in our model. Most of the measures were self-reported and may be subject to social desirability or other information bias, resulting in misclassification. Clinical diagnoses of depression and substance use disorders were not assessed. While we did account for PrEP use in our measure of unprotected anal sex, the measure did not account for PrEP adherence, and it is not known whether participants were taking PrEP at the time that they had condomless anal sex.

There are several limitations specifically related to the measure of structural stigma. First, this measure was operationalized only at the state level and did not include

other forms of structural stigma that are likely important for ASMM, such as community- or school-level policies and institutional norms (Pachankis et al., 2014). Second, while a strength of this study was that it included three levels of sexual stigma in the same model, it did not consider other types of stigma, such as stigma based on race or ethnicity. Future studies should be conducted to integrate the multilevel stigma and intersectional stigma frameworks. Third, structural stigma was examined as an independent variable to explore the hypothesis that structural stigma, interpersonal stigma, and individual stigma are part of the same pathway linked to HIV sexual risk behavior. However, structural stigma may also act as a moderator of the associations between interpersonal or individual stigma and health outcomes (Pachankis et al., 2014), which should be investigated in future studies on HIV risk among ASMM.

The data source did not include rejection sensitivity and concealment of sexual orientation, which are important proximal minority stressors (Meyer, 2003), nor did it include childhood sexual abuse and intimate partner violence, which are important to the theory of syndemic production (Stall et al., 2008). This study was not intended as a formal test of either theory. Rather, these theories were used to inform an investigation of multilevel stigma as a social determinant of HIV sexual risk behavior among ASMM.

Bootstrapping could not be used in the estimations of indirect effects due to the adjustment for clustering by state, which may have affected the standard errors. This was likely less of a limitation in the aggregate model and in the middle and late developmental groups, as a simulation study found that with larger sample sizes, Sobel estimates of standard errors are very similar to bootstrapped estimates (Lockwood & Mackinnon, n.d.).

Despite these limitations, this study contributes to a greater understanding of factors that produce health disparities among ASMM by addressing multiple gaps in the literature on sexual stigma as a social determinant of HIV risk. Although prominent theories of sexual minority health often refer to structural sources of stigma, such sources are rarely measured in quantitative studies. We also examined interpersonal and individual stigma as explanatory mechanisms, thereby offering a more comprehensive model of multilevel stigma. Similarly, this study contributes to the literature by specifying hypotheses about the social origins of HIV risk and psychosocial health problems, which are considered syndemic among ASMM. Many quantitative studies on syndemics exclusively examine the effects of syndemics, and structural measures are mostly absent from those studies that do examine the social origins of syndemics. Importantly, this study also addresses a gap in the literature on ASMM, not only by including ASMM under the age of 18, but also by examining developmental stage as a moderating variable.

Conclusion

This study provides new evidence of possible links between state-level structural stigma, sexual minority victimization, substance use, and HIV sexual risk behavior among ASMM. Efforts to intervene on the pathway from sexual stigma to HIV sexual risk behavior among ASMM should be developmentally-appropriate and target multiple levels of stigma to achieve the greatest impact. Given recent trends in state legislatures - 2021 was the only year in the past decade where anti-LGBT bills outnumbered LGBT-inclusive bills introduced in state legislatures (Human Rights Campaign, 2022) - there is a vital need both for continued research on the impact of structural stigma on HIV risk

and the evaluation and implementation of structural interventions to ultimately reduce health disparities among ASMM.

Chapter 3: The Impact of Psychosocial Health Problems on HIV Pre-Exposure Prophylaxis Uptake among Adolescent Sexual Minority Males

Introduction

Since the U.S. Food and Drug Administration (FDA) first approved HIV pre-exposure prophylaxis (PrEP) for adolescents in 2018, PrEP uptake among adolescent sexual minority males (ASMM) has been slow. Although there are limited data on PrEP uptake specific to ASMM (Hamilton et al., 2021), estimates suggest that uptake among youth is low. For example, individuals under age 25 have a higher unmet need for PrEP than any other age group (Siegler et al., 2018). Preliminary data from 2020 indicate that 16- to 24-year-olds have the lowest PrEP coverage nationally, at 12.9%, relative to other age cohorts (*The Six EHE Indicators*, 2021). One study conducted with a national cohort of 1,398 ASMM ages 13-18 identified over half of the sample as appropriate PrEP candidates, yet only 3% were currently taking PrEP (Moskowitz et al., 2021). Findings from a simulation study suggest that expanding PrEP programs for ASMM would lead to meaningful declines in incident HIV diagnoses (Hamilton et al., 2021).

Many behavioral, social, clinical, and structural factors limit more extensive use of PrEP in the U.S. (Mayer et al., 2020), and barriers exist at the patient-, provider-, and systems-levels. Barriers to PrEP use may be particularly high among ASMM. For example, while awareness of PrEP has increased among SMM overall (Finlayson et al., 2019), low awareness may still be a barrier to PrEP use among ASMM. In a sample of ASMM surveyed in 2015, only 16% reported awareness of PrEP (Thoma & Huebner, 2018). A survey of ASMM conducted in 2018 found that 55% had heard of PrEP before the study (Macapagal et al., 2020). Adolescents and adults may face common barriers to

PrEP use, such as concern about the cost and medication side effects, mistrust of the healthcare system and drug companies, PrEP stigma, low self-efficacy, and low HIV risk perception (Eaton et al., 2017; Golub et al., 2013; Halkitis et al., 2018; Mutchler et al., 2015; Smith et al., 2012). ASMM also face unique challenges in accessing PrEP due to their dependence on parents and providers (Huebner & Mustanski, 2020; Moskowitz et al., 2020) and legal, familial, and social issues surrounding consent and confidentiality (Tanner et al., 2020).

Theory-based investigations of barriers to PrEP uptake can identify mechanisms of change that are useful in designing interventions. The Information-Motivation-Behavioral Skills (IMB) model is a prominent theory of health behavior that was designed specifically for HIV-related behaviors. The IMB model hypothesizes that information, motivation, and behavioral skills are the fundamental determinants of preventive behavior (Fisher & Fisher, 1996). To promote the initiation and maintenance of a behavior, levels of these three factors should be increased. The key constructs in the IMB model are 1) information related to the behavior of interest; 2) motivation to engage in the behavior, including attitudes, perceived social support, and perceived vulnerability; and 3) behavioral skills, including objective skills and self-efficacy. In most cases, information and motivation are hypothesized to work through behavioral skills to affect preventive behavior, but may also directly affect preventive behavior.

In the context of PrEP uptake, the IMB model would hypothesize that an individual is most likely to initiate PrEP when they are well-informed about both PrEP and HIV transmission, motivated to take PrEP, and have the behavioral skills needed to do so (Dubov et al., 2018). The IMB model was found to perform well in explaining

willingness to use PrEP among people who use drugs (Shrestha et al., 2017), as well as PrEP intentions and use among SMM and transgender women and men over the age of 18 (Walsh, 2019). An IMB model of PrEP uptake has not been tested among ASMM, despite low rates of PrEP use in this population. The IMB model has, however, been applied to ASMM in the context of other health behaviors and has been used to inform HIV prevention interventions among ASMM (Mustanski, Moskowitz, Moran, Newcomb, et al., 2020; Ybarra et al., 2018).

In addition to the IMB model's main hypotheses described above, the IMB model also hypothesizes that situational and personal characteristics, such as depression and substance use, interfere with the cognitive processes that lead to preventive behavior (Fisher et al., 2006). In this way, these factors are hypothesized to moderate the associations between the IMB model constructs and behavioral outcomes. Dubov et al. (2018) acknowledged this hypothesis in their proposed IMB model of PrEP uptake, which specifies contextual factors, including substance use and psychological ill-health, that moderate the relationships between IMB model constructs and PrEP uptake. As Safren et al. (2010) state, depressive symptoms, such as sadness, loss of interest, feelings of worthlessness, and concentration problems, can "interfere with the process of making social cognitive judgments," and "could therefore interfere with the ability of important social-cognitive variables to predict health behaviors such as HIV transmission risk behavior." According to Horvath and colleagues (2014) in their study of an IMB model of antiretroviral therapy (ART) adherence, "drug use disrupts processes that are critical to information processing and adherence behavioral skills."

It is important to consider these factors in an IMB model of PrEP uptake among ASMM. Sexual minority youth are more likely to experience poor mental health and use high-risk substances compared to heterosexual youth (Centers for Disease Control and Prevention, 2020). According to minority stress theory and the theory of syndemic production, psychosocial health disparities among ASMM can be understood in the context of a stigmatizing environment that creates a confluence of health problems due to exposure to excess stress (Meyer, 2003; Stall et al., 2008). Psychosocial health problems, including depression and substance use, have been described as a "syndemic" among ASMM (Mustanski et al., 2014), in that they co-occur within the population, interact to exacerbate their individual adverse health effects, and are produced by conditions of social inequality.

The IMB model's hypothesis that psychosocial factors moderate the IMB model constructs is rarely tested (Fisher et al., 2006). However, a few studies provide evidence in support of this hypothesis. For example, a study conducted with undergraduate students found that the relationship between behavioral skills and condom accessibility was weaker among those who consumed more alcohol compared to those who consumed less alcohol (Harkabus et al., 2013). Neurocognitive impairment, which disproportionately affects people who use drugs, was found to weaken the associations between IMB model constructs and condom use, internal condom use, and clean needle use (Huedo-Medina et al., 2016). In a test of the social cognitive model among adult SMM living with HIV, condom use self-efficacy was not associated with sexual transmission risk among individuals who screened positive for depression, while it was associated with sexual transmission risk among individuals who screened negative for

depression (Safren et al., 2010). A study that examined interactions between cognitive variables and situational factors among Black adolescents ages 13 to 18 found that, among participants who always used drugs before sex, there was no difference in the frequency of condomless sex between those who had low HIV risk reduction motivation compared to those who had high HIV risk reduction motivation. However, HIV risk reduction motivation was associated with a decreased likelihood of condomless sex among those who never or sometimes used drugs before sex (Mustanski et al., 2013).

Not all evidence from the literature is consistent with the hypothesis that psychosocial factors are moderators of the IMB model. Horvath et al. (2014) found that depression did not moderate associations between IMB model constructs and adherence to ART among people living with HIV. However, moderation by substance use was still evident, such that the effect of ART adherence information on adherence behavior was not mediated by behavioral skills among those who reported recent use of illicit substances (Horvath et al., 2014).

As discussed above, a few studies have tested IMB models of PrEP uptake among adults, but none have tested whether psychosocial factors moderate the associations between IMB model constructs and PrEP uptake. A handful of studies from the syndemic literature have examined associations between psychosocial health problems and PrEP uptake, but they do not incorporate theories of health behavior such as the IMB model, making it challenging to interpret their divergent findings. For example, co-occurring mental health problems, substance use, and exposure to violence have been identified as barriers to PrEP uptake among Black women (Nydegger et al., 2021), female sex workers in the Mexico-U.S. border region (Jain et al., 2020), and Black SMM (Sullivan & Eaton,

2021). Other studies suggest the opposite association or no association with PrEP uptake. A count variable consisting of intimate partner violence, depression, and substance use was associated with greater PrEP interest, intentions, and comfort in discussing PrEP with a healthcare provider among Latina women but not among Black or White women (Willie et al., 2021). Another study found that a count variable comprised of polydrug use, intimate partner violence, depressive symptoms, and binge drinking was positively associated with PrEP use in a sample of Black SMM (Chandler et al., 2020). Among Latino SMM ages 18 to 29, a count variable consisting of depression, intimate partner violence, marijuana use, illicit polysubstance use, binge drinking, and childhood sexual abuse was not associated with PrEP awareness, willingness, or use, but it was associated with lower odds of PrEP adherence (Blashill et al., 2020).

The impact of psychosocial health problems on social cognitive processes involved in PrEP uptake is unknown. Understanding whether psychosocial health problems interfere with such processes is important, in part because social cognitive processes are often targeted in interventions to increase PrEP use. For example, an intervention currently underway aims to improve engagement in PrEP care among Black SMM ages 18 to 35 by providing PrEP-related informational and motivational materials and by building PrEP-related behavioral skills (Rouffiac et al., 2020). Preliminary evidence suggests that addressing psychosocial health problems as part of a PrEP navigation intervention can increase PrEP linkage, uptake, and adherence among SMM and transgender women (Reback et al., 2019). This study did not examine the cognitive mechanisms of the intervention effects. An IMB-based intervention to increase PrEP use may be less effective in the presence of psychosocial health problems that have been

identified as a syndemic among ASMM. As Stall et al. (2003) state, “the existence of syndemics may make it difficult for some MSM [men who have sex with men] to respond to the messages of standard HIV prevention programs.”

Moreover, theories of syndemics, including the theory of syndemic production, emphasize the interdependence of health problems that are concentrated within populations as a result of inequitable social conditions (Singer, 2003; Stall et al., 2008). Studies have demonstrated worse outcomes related to HIV (Stall et al., 2003) and suicide (Mustanski et al., 2014) among individuals with greater numbers of co-occurring psychosocial health problems. Psychosocial health problems are often associated with each other, such that, for instance, ASMM with internalizing mental health symptoms are also more likely to experience problematic alcohol use (Perry et al., 2019). Therefore, it is important not only to examine whether psychosocial health problems individually are moderators of an IMB model of PrEP uptake, but also whether co-occurring psychosocial health problems modify the associations between PrEP uptake and PrEP-related information, motivation, and behavioral skills. This approach acknowledges that psychosocial health problems often do not occur in isolation and that individuals with co-occurring psychosocial health problems may experience even greater barriers to PrEP uptake than individuals without co-occurring psychosocial health problems.

In sum, the theoretical and empirical literature suggests that the IMB model may predict PrEP uptake among ASMM and that psychosocial health problems may be a barrier to PrEP use among ASMM. Furthermore, the IMB model’s hypothesis that psychosocial health problems modify the effects of IMB model constructs on preventive

behavior suggests an overlap between the IMB model literature and the syndemics literature that has yet to be explored in the context of PrEP uptake.

This study first aimed to test an IMB model of willingness and intention to use PrEP among ASMM, with the hypotheses that PrEP-related information, motivation, and behavioral skills would be positively associated with willingness and intention to use PrEP. Specifically, we hypothesized that information and motivation would have indirect associations with willingness and intention to use PrEP via behavioral skills (Figure 3.1).

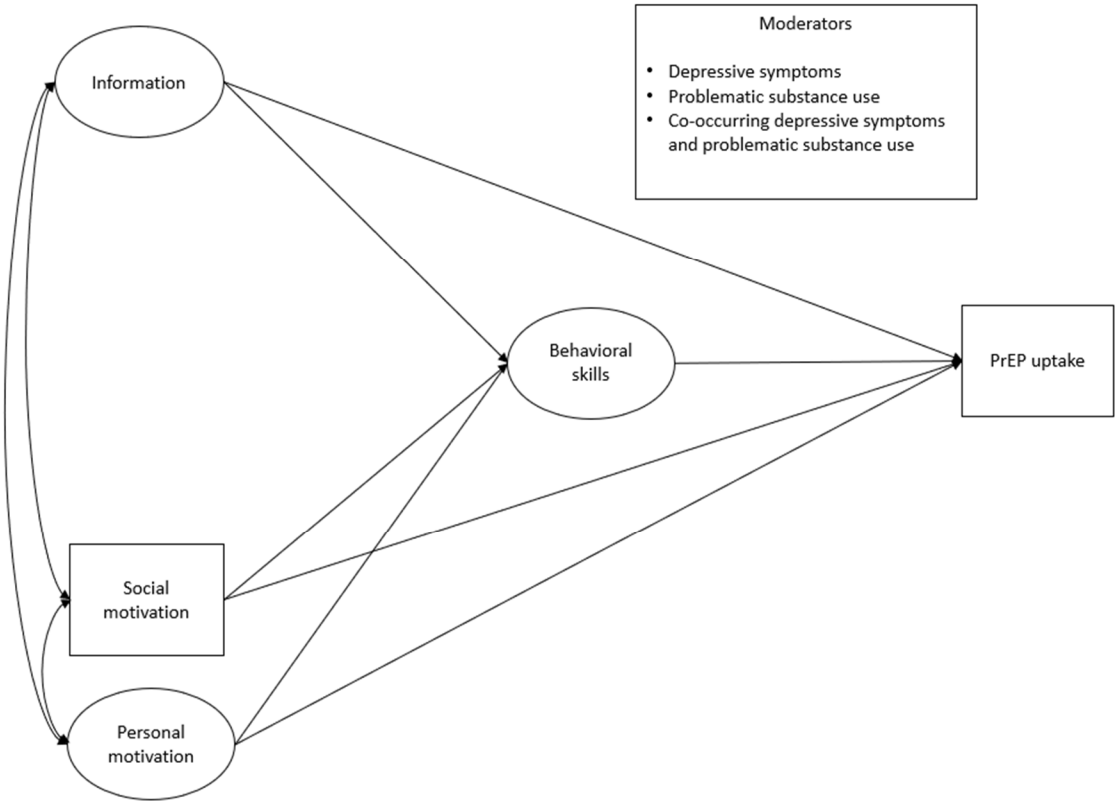

Figure 3.1. Hypothesized conceptual model of an Information-Motivation-Behavioral Skills (IMB) model of PrEP uptake among ASMM with psychosocial health problems as potential moderators

The second aim was to determine whether psychosocial health problems that disproportionately affect ASMM interfere with social cognitive processes involved in willingness and intention to use PrEP. We tested the hypothesis that the magnitude of the

associations between the IMB model constructs and willingness and intention to use PrEP would decrease in the presence of individual psychosocial health problems, specifically depressive symptoms and problematic substance use. Additionally, we hypothesized that the IMB model associations would be stronger among ASMM reporting no or fewer psychosocial health problems compared to those reporting co-occurring psychosocial health problems.

Methods

Study Design

Cross-sectional baseline data from a randomized controlled trial testing the efficacy of an HIV prevention intervention ("SMART") were used to investigate the aims of this study. The SMART program consists of three stepped-care eHealth interventions to reduce condomless anal sex and increase condom self-efficacy, condom use intentions, and HIV testing among ASMM. Details of the study design and methodology have been published elsewhere (Mustanski, Moskowitz, Moran, Newcomb, et al., 2020).

Sample

The baseline sample for the SMART program consisted of 1,624 ASMM who were enrolled between April 2018 and July 2020. Participants who met the following criteria were eligible to enroll in the study: 1) assigned male sex at birth, 2) identified as a sexual minority or reported attraction to cisgender men, 3) reported an HIV-negative or unknown HIV status, 4) ever engaged in sexual contact with another person, defined as touching another person's genitals or engaging in oral, vaginal, or anal sex, 5) were age 13-18, 6) had access to or used the internet, 7) could read and speak English or Spanish at or above a sixth-grade level, and 8) lived in the U.S. including Puerto Rico, Guam, and

American Samoa. Participants were recruited using paid advertising on social media and web-based engagement on geospatial dating apps and other social media. Community partners providing services to adolescents also supported recruitment by sharing information about the study on their social media, websites, and mailing lists. The Northwestern University IRB granted a waiver of signed documentation of informed consent or assent and a waiver of parental permission for participants under the age of 18. Participants answered four decisional capacity questions and were interviewed by study staff before enrolling in the study. Participants were compensated with $25 for completing the baseline online survey.

For this analysis, the sample was restricted to individuals who had never used PrEP, excluding 62 participants. The analytic sample also excluded an additional 198 participants who enrolled in the trial before one of the key measures used in this analysis was added to the baseline survey (see "motivation" section below), resulting in a final analytic sample size of 1,364.

Data Collection

All measures used in this analysis are from the SMART baseline survey. Participants completed an eligibility survey, provided consent, took the baseline survey, and were then able to access the first SMART intervention. The data that were used for this analysis were collected before exposure to the intervention.

Measures

IMB model constructs. IMB model constructs included PrEP-related information, personal motivation, social motivation, and behavioral skills.

Information. PrEP-related information was measured using 11 items. Consistent with Dubov et al. (2018)'s modified IMB model of PrEP uptake, the information construct consisted of information related to both HIV and PrEP. HIV information was assessed with ten true or false questions: "It is impossible to get HIV from an HIV-positive partner who has an undetectable viral load," "Current guidelines say that guys who have sex with other guys should get tested for HIV at least every six months," "A natural skin (lamb skin) condom works better against HIV than does a latex condom," "A person will NOT get HIV if (she or) he is taking antibiotics," "If you only have sex once with a partner, you cannot get HIV from them," "People on HIV medications cannot spread HIV," "Everybody who has HIV knows that they have HIV," "When using condoms during sex it is safer to use water-based lubricants than oil-based lubricants," "Only the receptive/'bottom' partner is at risk of being infected with HIV during anal sex," "There is a medication you can take after being exposed to HIV that reduces your risk of contracting HIV." PrEP information was defined using the item: "Taking pre-exposure prophylaxis (a pill, also known as PrEP or Truvada) regularly can reduce the risk of contracting HIV from an HIV-positive sex partner." As in Shrestha et al. (2017)'s test of an IMB model of willingness to use PrEP, correct responses were scored as "1," and incorrect responses were scored as "0."

Motivation. PrEP-motivation was measured using four items: three for personal motivation and one for social motivation, which were analyzed separately (Amico et al., 2009; Horvath et al., 2014). Items considered for the personal motivation measure included attitudes and perceived vulnerability to HIV. Attitudes were assessed using the item "Talking to a partner about pre-exposure prophylaxis (a pill, also known as PrEP or

Truvada or Descovy) would be…" rated on a 5-point scale from 1 = "Very unimportant" to 5 = "Very important." Two measures of perceived vulnerability to HIV were included in the SMART baseline survey: 1) "How likely do you think it is you will get HIV if you have sex without a condom or PrEP?" and 2) "How likely do you think it is that you will become HIV-positive at some point in your lifetime?" These items were measured on a 5-point Likert-type scale ranging from 1= "Very unlikely" to 5 = "Very likely." In a previous study, a latent measure of PrEP-motivation with four indicators that included both attitudes toward PrEP use and perceived vulnerability to HIV performed well in confirmatory factor analysis (Shrestha et al., 2017). The social motivation measure consisted of perceived social support from parents: "How do you think your parent(s) would react if you asked if you could start taking PrEP? They would be…" rated on a 4-point scale from 1 = "Very unsupportive" to 4 = "Very supportive." This item was added to the SMART baseline survey in July 2018.

Behavioral skills. PrEP-behavioral skills were measured using three items. The IMB model of PrEP uptake identifies self-efficacy as a key component of the behavioral skills construct. Self-efficacy was assessed using the following items: 1) "How confident are you that you would be able to attend these doctor appointments [for PrEP care] every three months?" which was measured using a 7-point scale ranging from 1 = "Not at all confident" to 7 = "Extremely confident," and 2) "How confident are you that you could get pre-exposure prophylaxis (PrEP) where you live?" rated on a 4-point scale from 1 = "Not all confident" to 4 = "Very confident." Dubov et al. (2018) also included action planning in their modified IMB model, which refers to the process of specifying "when, where, and how to act" and involves identifying a provider, among other planning

processes. Action planning was assessed using the item "Imagine you were interested in starting PrEP. Do you know of a doctor or medical provider that would prescribe PrEP to you?" rated on a 4-point scale from 1 = "Yes, definitely" to 4 = "No, definitely not." This item was reverse coded for analysis.

Dependent variables. Previous studies of IMB models of PrEP uptake examined willingness to use PrEP, intentions to use PrEP, or PrEP use as outcomes (Shrestha et al., 2017; Walsh, 2019). In this analysis, willingness and intention to use PrEP were analyzed as two separate dependent variables. PrEP use was not included as a dependent variable given that few participants reported using PrEP (n = 62; 4%).

Willingness to use PrEP. Willingness to use PrEP was defined using the following item: "How likely would you be to take PrEP if you could get it for free?" rated on a 5-point scale from 1 = "I would definitely take it" to 5 = "I would definitely not take it." Willingness to use PrEP was coded "1" if a participant reported that they would definitely or probably take it and "0" if a participant reported that they might take it, would probably not take it, or would definitely not take it. The use of a binary variable coded in this manner is consistent with previous studies of willingness to use PrEP (Grov et al., 2015; Rendina et al., 2017; Shrestha et al., 2017).

Intention to use PrEP. Intention to use PrEP was defined using the following item: "PrEP is currently available with a prescription and most insurance companies will cover the costs. Do you plan to start taking PrEP?" rated on a 5-point scale from 1 = "Yes, I will definitely start taking PrEP" to 5 = "No, I will definitely not start taking PrEP." Intention to use PrEP was coded "1" if a participant reported that they definitely or probably will start taking PrEP and "0" if a participant reported that they weren't sure,

probably will not start taking PrEP, or definitely will not start taking PrEP. The use of a binary variable coded in this manner is consistent with previous studies of intention to use PrEP (Blair et al., 2021; Rendina et al., 2017).

Moderators.

Depressive symptoms. The Patient-Reported Outcomes Measurement Information System (PROMIS) Depression - Short Form 8b was used to measure depressive symptoms over the previous week. Symptoms included self-reported negative mood, views of self, social cognition, and decreased positive affect and engagement. For example, participants reported how often they felt worthless or hopeless in the past seven days using a 5-point scale ranging from 1 = "Never" to 5 = "Always." A total score was computed by calculating a depression raw score (i.e., the sum of item responses divided by the number of items answered), and converting the raw score to a T-score. PROMIS scoring defines a T-score of less than 55 as no to slight depression, 55-59.9 as mild depression, 60-69.9 as moderate depression, and 70 and over as severe depression. Participants with a T-score of at least 60 were considered to have depressive symptoms in this analysis. This is consistent with other studies that have used a PROMIS score of 60 to indicate the threshold for clinically meaningful depressive symptomatology (Przedworski et al., 2015).

Problematic alcohol use. Alcohol use in the past three months was measured in the SMART baseline survey with the three-item AUDIT-C scale. The AUDIT-C measures levels of alcohol consumption, rather than negative consequences of alcohol use. Participants who reported that they had used alcohol in the last three months were asked 1) "How often do you have a drink containing alcohol?" (0 = "Never," 1 =

"Monthly or less," 2 = "2-4 times a month," 3 = "2-3 times a week," 4 = "4 or more times a week"), 2) "How many drinks containing alcohol do you have on a typical day when you are drinking?" (0 = "1 or 2," 1 = "3 or 4," 2 = "5 or 6," 3 = "7 to 9," 4 = "10 or more), and 3) "How often do you have six or more drinks on one occasion?" (0 = "Never," 1 = "Less than monthly," 2 = "Monthly," 3 = "Weekly," 4 = "Daily or almost daily"). Participants who did not report lifetime use of alcohol were assigned a score of "0." Cronbach's alpha was 0.71. For this analysis, item responses were summed to create a final score for each participant, with higher scores indicating higher levels of alcohol consumption in the past three months. This scoring method is consistent with previous research (English et al., 2022; Rubinsky et al., 2013). Based on a previous study that validated the AUDIT-C scale in a sample of adolescents ages 14 to 18, a cut-off of five was used to indicate a positive screen for problematic alcohol use (Rumpf et al., 2013).

Regular marijuana use. Regular marijuana use was assessed using one item from the Cannabis Use Disorders Identification Test (CUDIT), which is used to identify problematic marijuana use. This item measures the frequency of marijuana use in the past three months (never, monthly or less, 2-4 times a month, 2-3 times a week, or 4 or more times a week). This variable was dichotomized for analysis, where regular marijuana use was defined as using marijuana four or more times a week. This definition is similar to that used in studies of syndemics among young SMM (Mustanski et al., 2007, 2014).

Polydrug use. Drug use was assessed by asking participants to report lifetime and past three-month use of the following non-prescription drugs: synthetic marijuana, cocaine or crack, heroin, methamphetamines, GHB, ketamine, poppers, inhalants, hallucinogens or psychedelics, ecstasy, and other drugs. Polydrug use was coded "1" if a

participant reported using two or more of these drugs in the past three months and "0" if a participant reported using none or only one of these drugs in the past three months. This measure excluded alcohol and marijuana use. Synthetic marijuana, or synthetic cannabinoids, was included in this measure while marijuana was not because it is used less commonly by adolescents, similar to the other drugs included in the polydrug use measure (in this sample, lifetime use of synthetic marijuana = 2.6% vs. lifetime use of marijuana = 53%). Tobacco use was not assessed in the baseline survey. Polydrug use is often used as a measure of substance use in studies of psychosocial syndemics among SMM (Chandler et al., 2020; Mimiaga et al., 2015; Mustanski et al., 2017).

Covariates. The following sociodemographics assessed by the SMART baseline survey were considered for inclusion as covariates in the analysis: age, race/ethnicity, sexual identity, outness, urban/rural residence, family receipt of public assistance, employment status, student status, living with parents, and perceived economic strain. Outness was considered as a potential covariate given previous research describing fear of being outed as a reason for not using PrEP (Cahill et al., 2021; Moskowitz et al., 2020). Perceived economic strain was measured using the 8-item Responses to Stress Questionnaire, which asked participants to report how often they experienced economic strain in their entire life (e.g., "My parents didn't have enough money to pay the bills," "We didn't have enough money to go places I wanted to go") and was rated on a 4-point scale ranging from 0 = "Not at all" to 3 = "Almost every day." Scores for each stressor were summed to create a total economic strain score (Wadsworth & Compas, 2002). Cronbach's alpha in this sample was 0.92. Education level was not included because it was highly correlated with age. Family income was not measured in the baseline survey.

Statistical Analysis

Preliminary analysis. Descriptive statistics and bivariate correlations were calculated to summarize the sample. Frequencies were generated to describe the prevalence of psychosocial health problems individually and in combination. Distributional differences in the key variables stratified by presence or absence of psychosocial health problems were assessed using chi-square tests and t-tests. Multicollinearity was assessed using a bivariate correlation matrix and PROC REG to determine whether the variables were within recommended ranges (correlations < 0.80, tolerance values > 0.10, and variance inflation < 10). Univariate and bivariate analyses were performed using SAS software version 9.4 (SAS Institute Inc., Cary, NC, USA).

Handling of missing data. Of the key variables, only the two perceived vulnerability items were missing data. They were each 99.9% complete (missing n = 1). Of the covariates, only urban/rural residence was missing data (n = 14). Logistic regression models predicting missingness for each variable with missing data using the key variables and covariates as predictors revealed no significant associations.

Primary analysis. Structural equation modeling (SEM) was used to investigate both aims in Mplus version 7.31 (Muthén & Muthén, 2012). For the first aim, the hypothesized pathways were tested in the aggregate sample (Figure 3.1). Social motivation, willingness to use PrEP, and intention to use PrEP were treated as manifest variables. Information, personal motivation, and behavioral skills were assessed as latent factors. In the first step of the primary analysis, confirmatory factor analysis (CFA) was used to test the measurement models of the latent factors. The items for each construct were loaded onto the respective latent factors as follows: information was a latent factor

indexed by its 11 indicators, personal motivation was a latent factor indexed by its three indicators, and behavioral skills was a latent factor indexed by its three indicators. Model estimation was performed using the robust weighted least squares (WLSMV) method, which is robust to missing data (Asparouhov & Muthén, 2010). To determine the scale of the latent factors, the variance of the factors was constrained to one, and the indicator with the strongest loading was identified. The measurement models were then respecified to constrain the loading of that indicator to one. Error covariances between indicators were added based on modification indices if they were supported by theory. Individual items were removed from their respective factors if they had a non-significant factor loading ($p > 0.05$) or an unstandardized factor loading estimate < 0.40 (Shrestha et al., 2017).

Next, separate full SEM with measurement and structural models was used for each of the two dependent variables to test the hypothesized associations. Willingness and intention to use PrEP were modeled as two separate dependent variables based on previous research showing meaningful distinctions between these two variables, such that there are significant differences between individuals who are willing but not intending to take PrEP and those who are willing and intending to take PrEP (Rendina et al., 2017).

Because cross-sectional data lack temporal precedence, indirect effects were tested, rather than mediation. Mediation necessarily implies "the transmission of changes from cause to mediator to outcome," while "the term 'indirect effect' may still apply if directionality assumptions in a cross-sectional study have a strong rationale" (Kline, 2015), as they do in this theory-driven study. Because of the binary dependent variables,

model estimation was again performed using WLSMV. The three exogenous variables, information, personal motivation, and social motivation, were allowed to covary.

The second aim was investigated using multigroup analysis. A series of separate SEM models were specified to determine whether each of the psychosocial health problems individually (e.g., depressive symptoms vs. no depressive symptoms) moderated the associations between the IMB model constructs and the two dependent variables (Figure 3.1). Additionally, a variable was constructed to indicate the number of psychosocial health problems reported. The count variable, ranging from 0 to 2, was intended to assess whether the associations hypothesized by the IMB model are weaker among individuals with co-occurring psychosocial health problems.

Before testing the structural model, measurement invariance testing was performed to determine whether the measurement model was invariant by presence vs. absence of each psychosocial health problem. The CFA model was first analyzed separately in each group. Separate models were then estimated for each group but were analyzed simultaneously in the same model. This model was then used to test for configural invariance, which assumed only a similar factor structure and allowed the factor loadings and intercepts to differ across groups. The metric model, which adds equality constraints to factor loadings, was not tested because several indicators were binary (Brown, 2015; Muthén & Muthén, 2012). Instead, the next step was to test the scalar model, which added equality constraints on all factor loadings, intercepts, and thresholds. A chi-square difference test was used to determine whether the equality constraints significantly degraded the model fit. This was performed with the DIFFTEST command given the use of WLSMV estimation (Muthén & Muthén, 2012). Measurement

invariance was supported with a p-value ≥ 0.05 for the difference test between the scalar model and the configural model, indicating that the equality constraints did not significantly degrade model fit.

After examining invariance of the measurement model, multigroup analysis was used to evaluate differences in the structural paths across groups. If there was no significant difference in the measurement model across groups, we held the measurement model invariant and tested for equivalence in the structural model. Two models were estimated for each dependent variable and for each potential moderator: 1) a model that allowed structural paths to vary across groups and 2) a model that constrained all paths to equality across groups. The DIFFTEST command was used to test whether the constraints significantly degraded the model. If the chi-square difference test was significant ($p < 0.05$), modification indices were inspected to determine which paths should be freed. One path was freed at a time until the chi-square difference test was not statistically significant.

Model fitness was evaluated using the Bentler comparative fit index (CFI), root mean square error of approximation (RMSEA), and the Tucker-Lewis index (TLI). The standardized root mean squared residual (SRMR) was not available with WLSMV estimation. A CFI and TLI ≥ 0.90 and an RMSEA ≤ 0.08 indicated good model fit. Mplus calculated 90% confidence intervals (CI) for the RMSEA to provide information about the precision of the estimate. A narrow 90% CI that included or was close to zero indicated good fit. The chi-square test for model fit is reported but was not used to assess fit because it is highly influenced by sample size (Brown, 2015; Hu & Bentler, 1998). Modification indices were inspected to inform model respecification if model fit was

poor. Respecification was performed if the modification indices were consistent with theory. Unadjusted and adjusted models were tested. Adjusted models included covariates that were associated with the dependent variables in bivariate analysis at $p < 0.20$. Bootstrapping with 1,000 samples was used to generate standard errors and 95% confidence intervals for the indirect effects. An indirect effect was considered significant if its 95% confidence interval did not contain zero.

Finally, a sensitivity analysis was conducted to examine whether the results differed when the analysis was restricted to participants who had ever had anal sex with a male partner (n = 951).

Results

Sample characteristics

The analytic sample consisted of 1,364 participants. Sociodemographic characteristics are included in Table 3.1. The sample had a mean age of 16.8 years and was approximately 36% Hispanic/Latino, 12% non-Hispanic Black/African American, 38% non-Hispanic White, and 15% were another race or multiracial. Most participants identified as gay (66%), were either out to most people or out to everyone (68%), lived with their parents or caregivers (81%), were students (90%), were not employed (60%), and lived in urban areas (84%). A third of participants (34%) reported that their family received public assistance. Participants predominantly lived in the South (39%), followed by the West (25%), Midwest (18%), Northeast (15%), and Puerto Rico (3%). Most participants (74%) were willing to use PrEP, while approximately a quarter (27%) intended to use PrEP. Correlations between model variables are shown in Table 3.2.

Psychosocial health problems

600 participants (44%) met the criteria for clinically significant depressive symptomatology, 137 (10%) were considered to have problematic alcohol use, 112 (8%) participants reported regular marijuana use, and 32 (2%) reported polydrug use. Regular marijuana use, problematic alcohol use, and polydrug use were collapsed into an aggregate "problematic substance use" binary variable (0 = none/1 = any) for further analyses because of insufficient variability within the individual substance use categories. 223 participants (16%) were considered to have problematic substance use. 639 participants (47%) had neither depressive symptoms nor problematic substance use, 502 (37%) had depressive symptoms but not problematic substance use, 125 (9%) had problematic substance use but not depressive symptoms, and 98 (7%) had both depressive symptoms and problematic substance use. Since the number of participants with both depressive symptoms and problematic substance use was so small, multigroup analysis using the number of psychosocial health problems as the grouping variable could not be performed.

In bivariate analysis, participants with depressive symptoms scored lower on information, social motivation, and behavioral skills but higher on personal motivation compared to participants without depressive symptoms (Table 3.3). Participants with problematic substance use scored either no differently or lower on personal motivation but higher on social motivation and behavioral skills than participants without problematic substance use. There was no difference in willingness to use PrEP among participants with and without depressive symptoms (75% vs. 72%; $\chi^2(1) = 1.34$, $p = 0.25$). Participants with problematic substance use were significantly more likely to be

Table 3.1. Sociodemographic characteristics of ASMM (N=1364)

	Total	Depressive symptoms		Test statistic[a]	Problematic substance use		Test statistic[a]
	N (%)	Yes (n = 600)	No (n = 764)		Yes (n = 190)	No (n = 1174)	
Race/ethnicity							
Black/African American	160 (11.7)	61 (10.2)	99 (13.0)	4.82	21 (11.1)	139 (11.8)	4.59
Latino	484 (35.5)	211 (35.2)	273 (35.7)		68 (35.8)	416 (35.4)	
Other/multiracial	206 (15.1)	102 (17.0)	104 (13.6)		20 (10.5)	186 (15.8)	
White	514 (37.7)	226 (37.7)	288 (37.7)		81 (42.6)	433 (36.9)	
Sexual identity							
Bisexual	350 (25.7)	151 (25.2)	199 (26.1)	5.94	58 (30.5)	292 (24.9)	2.74
Gay	899 (65.9)	386 (64.3)	513 (67.2)		117 (61.6)	782 (66.6)	
Other	115 (8.4)	63 (10.5)	52 (6.8)		15 (7.9)	100 (8.5)	
Outness							
Out to everyone	347 (25.4)	140 (23.3)	207 (27.1)	2.55	60 (31.6)	287 (24.5)	6.33*
Out to most people	574 (42.1)	258 (43.0)	316 (41.4)		81 (42.6)	493 (42.0)	
Not out or only to a few people	443 (32.5)	202 (33.7)	241 (31.5)		49 (25.8)	394 (33.6)	
Gender identity							
Cisgender male	1282 (94.0)	549 (91.5)	733 (95.9)	11.74***	174 (91.6)	1108 (94.4)	2.27
Other gender identity	82 (6.0)	51 (8.5)	31 (4.1)		16 (8.4)	66 (5.6)	
Region							
Midwest	243 (17.8)	109 (18.2)	134 (17.5)	2.21	37 (19.5)	206 (17.6)	1.54
Northeast	208 (15.3)	85 (14.2)	123 (16.1)		33 (17.4)	175 (14.9)	
Puerto Rico	41 (3.0)	16 (2.7)	25 (3.3)		6 (3.2)	35 (3.0)	
South	530 (38.9)	231 (38.5)	299 (39.1)		69 (36.3)	461 (39.3)	
West	342 (25.1)	159 (26.5)	183 (24.0		45 (23.7)	297 (25.3)	
Urban residence[b]	1129 (83.6)	496 (83.4)	633 (83.8)	0.06	164 (86.8)	965 (83.1)	1.59
Family receipt of public assistance	458 (33.6)	234 (39.0)	224 (29.3)	14.12***	65 (34.2)	393 (33.5)	0.04
Employed	551 (40.4)	242 (40.3)	309 (40.5)	0.00	105 (55.3)	446 (38.0)	20.27****

Lives with parents	1099 (80.6)	497 (82.8)	602 (78.8)	3.50	132 (69.5)	967 (82.4)	17.37****
Current student	1233 (90.4)	533 (88.8)	700 (91.6)	3.01	157 (82.6)	1076 (91.7)	15.33****
Mean age (SD)	16.8 (1.28)	16.6 (1.3)	16.8 (1.2)	2.72**	17.3 (0.9)	16.7 (1.3)	-8.59****
Mean perceived economic strain (SD)	6.77 (5.42)	8.0 (5.7)	5.8 (5.0)	-7.24****	7.4 (5.9)	6.7 (5.3)	-1.53

ASMM (adolescent sexual minority males), SD (standard deviation).
*p<0.05, **p<0.01, ***p<0.001, ****p<0.0001.
[a] Test statistics are chi-square tests for categorical variables and t-tests for continuous variables.
[b] n=1350 due to missing data.

Table 3.2. Bivariate correlations between key variables (N=1364)

	1	2	3	4	5	6	7	8	9	10
1. Information	–									
2. Personal motivation item 1[a]	-0.00	–								
3. Personal motivation item 2[b]	-0.03	0.21****	–							
4. Personal motivation item 3[c]	-0.08**	0.07**	0.21****	–						
5. Social motivation[d]	0.02	0.08**	0.02	-0.04	–					
6. Behavioral skills item 1[e]	0.11****	0.12****	0.00	-0.03	0.27****	–				
7. Behavioral skills item 2[f]	0.22****	0.02	-0.05	-0.09***	0.20****	0.21****	–			
8. Behavioral skills item 3[g]	0.16****	0.11****	-0.02	-0.10***	0.30****	0.31****	0.38****	–		
9. Willingness to use PrEP	0.10***	0.06*	0.06*	0.13****	0.10***	0.24****	0.00	0.06*	–	
10. Intention to use PrEP	0.08**	0.10***	0.10***	0.06*	0.13****	0.21****	0.10***	0.15****	0.31****	–
Range	0-9	1-5	1-5	1-5	1-4	1-7	1-4	1-4	--	--
Mean	6.22	3.91	3.50	2.26	2.30	4.74	2.50	2.50	--	--
SD	1.89	1.01	1.05	1.07	1.01	1.80	1.02	0.91	--	--

PrEP (pre-exposure prophylaxis), SD (standard deviation).

[a]"Talking to a partner about pre-exposure prophylaxis (a pill, also known as PrEP or Truvada or Descovy) would be…"

[b]"How likely do you think it is you will get HIV if you have sex without a condom or PrEP?"

[c]"How likely do you think it is that you will become HIV-positive at some point in your lifetime?"

[d]"How do you think your parent(s) would react if you asked if you could start taking PrEP? They would be…"

[e]"How confident are you that you would be able to attend these doctor appointments every 3 months?"

[f]"How confident are you that you could get pre-exposure prophylaxis (PrEP) where you live?"

[g]"Imagine you were interested in starting PrEP. Do you know of a doctor or medical provider that would prescribe PrEP to you?"

*p<0.05; **p<0.01; ***p<0.001; ****p<0.0001.

willing to use PrEP than participants without problematic substance use (81% vs. 72%; $\chi^2(1) = 6.94$, $p = 0.008$). There was no difference in intention to use PrEP among participants with and without depressive symptoms (26% vs. 27%; $\chi^2(1) = 0.32$, $p = 0.57$) or among participants with and without problematic substance use (31% vs. 26%; $\chi^2(1) = 2.92$, $p = 0.09$).

Table 3.3. Distribution of IMB model constructs stratified by psychosocial health problems (N=1364)

	Total	Depression status		Test statistic[a]	Problematic substance use		Test statistic[a]
	Mean (SD)	Yes (n = 600)	No (n = 764)		Yes (n = 223)	No (n = 1141)	
Information	6.22 (1.89)	6.06 (1.95)	6.35 (1.84)	2.85**	6.40 (1.85)	6.19 (1.90)	-1.59
Personal motivation item 1[b]	3.91 (1.01)	3.94 (1.00)	3.89 (1.02)	-0.80	3.83 (1.03)	3.93 (1.01)	1.24
Personal motivation item 2[c]	3.50 (1.05)	3.58 (1.02)	3.43 (1.06)	-2.70**	3.35 (1.10)	3.53 (1.04)	2.21*
Personal motivation item 3[d]	2.26 (1.07)	2.42 (1.08)	2.14 (1.04)	-4.73****	2.33 (1.11)	2.25 (1.06)	-1.03
Social motivation[e]	2.30 (1.01)	2.10 (0.99)	2.46 (1.00)	6.56****	2.45 (1.02)	2.27 (1.00)	-2.42*
Behavioral skills item 1[f]	4.74 (1.80)	4.63 (1.84)	4.84 (1.77)	2.17*	5.11 (1.68)	4.67 (1.82)	-3.52***
Behavioral skills item 2[g]	2.50 (1.02)	2.37 (1.03)	2.59 (1.00)	3.98****	2.74 (1.02)	2.45 (1.01)	-3.89***
Behavioral skills item 3[h]	2.50 (0.91)	2.41 (0.90)	2.57 (0.92)	3.10**	2.64 (0.98)	2.47 (0.90)	-2.40*
Willing to use PrEP (N, %)	1004 (73.6)	451 (75.2)	553 (72.4)	1.34	180 (80.7)	824 (72.2)	6.94**
Intention to use PrEP (N, %)	365 (26.8)	156 (26.0)	209 (27.4)	0.32	70 (31.4)	295 (25.9)	2.92

ASMM (adolescent sexual minority males), IMB (information-motivation-behavioral skills), PrEP (pre-exposure prophylaxis), SD (standard deviation).

[a]Test statistics are chi-square tests for binary dependent variables and t-tests for IMB model constructs

[b]"Talking to a partner about pre-exposure prophylaxis (a pill, also known as PrEP or Truvada or Descovy) would be…"

[c]"How likely do you think it is you will get HIV if you have sex without a condom or PrEP?"

[d]"How likely do you think it is that you will become HIV-positive at some point in your lifetime?"

[e]"How do you think your parent(s) would react if you asked if you could start taking PrEP? They would be…"

[f]"How confident are you that you would be able to attend these doctor appointments every 3 months?"

[g]"How confident are you that you could get pre-exposure prophylaxis (PrEP) where you live?"

[h]"Imagine you were interested in starting PrEP. Do you know of a doctor or medical provider that would prescribe PrEP to you?"

*p<0.05, **p<0.01, ***p<0.001, ****p<0.0001

Aim 1 results

Measurement model. In CFA, two indicators from the information factor ("It is impossible to get HIV from an HIV-positive partner who has an undetectable viral load" and "Current guidelines say that guys who have sex with other guys should get tested for HIV at least every six months") and one indicator from the personal motivation factor ("Talking to a partner about pre-exposure prophylaxis (a pill, also known as PrEP or Truvada or Descovy) would be…[very unimportant to very important]") were removed from the model due to unstandardized factor loadings < 0.40. This personal motivation item was more a measure of attitudes toward disclosure of PrEP use to partners than attitudes toward PrEP itself, which may have contributed to the low factor loading. After re-specifying the measurement model, the factor loading for one of the two remaining personal motivation indicators ("How likely do you think it is that you will become HIV-positive at some point in your lifetime?") was no longer significant, and was dropped from the CFA. Because that left only one item for the personal motivation factor ("How likely do you think it is you will get HIV if you have sex without a condom or PrEP?"), this item was operationalized as a manifest variable in further analyses.

Error covariances were added between the following indicators of the information latent factor based on modification indices: 1) between "There is a medication you can take after being exposed to HIV that reduces your risk of contracting HIV" and "Taking pre-exposure prophylaxis (a pill, also known as PrEP or Truvada or Descovy) regularly can reduce the risk of contracting HIV from an HIV-positive sex partner," 2) between "People on HIV medications cannot spread HIV" and "A person will not get HIV if (she or) he is taking antibiotics," and 3) between "When using condoms during sex it is safer

to use water-based lubricants than oil-based lubricants" and "A natural skin (lamb skin) condom works better against HIV than does a latex condom." The first set of indicators both relate to information about biomedical HIV prevention methods (post-exposure prophylaxis and PrEP, respectively), and they had similar wording. The second set of indicators both relate to information about HIV treatment. The third set of indicators both relate to information about condoms. An error covariance was added between the following indicators of the behavioral skills latent factor based on modification indices: "How confident are you that you could get pre-exposure prophylaxis (PrEP) where you live?" and "Imagine you were interested in starting PrEP. Do you know of a doctor or medical provider that would prescribe PrEP to you?" Both indicators relate to accessing PrEP.

The re-specified measurement model fit the data well ($\chi^2(49) = 127.51$, $p = 0.000$; RMSEA = 0.03 [90% CI = 0.03-0.04]; CFI = 0.96; TLI = 0.95). Standardized factor loadings and R-square estimates, or the percentage of variance in the indicator accounted for by the latent factor, are shown in Table 3.4.

Table 3.4. Results from CFA testing the PrEP-related information and behavioral skills measurement model

Item	Standardized factor loading	R-square
Information		
1: It is impossible to get HIV from an HIV-positive partner who has an undetectable viral load [False]	--	--
2: Current guidelines say that guys who have sex with other guys should get tested for HIV at least every six months [True]	--	--
3: A natural skin (lamb skin) condom works better against HIV than does a latex condom [False]	0.53	0.28
4: A person will NOT get HIV if (she or) he is taking antibiotics [False]	0.69	0.48
5: If you only have sex once with a partner, you cannot get HIV from them [False]	0.73	0.54
6: People on HIV medications cannot spread HIV [False]	0.45	0.21
7: Everybody who has HIV knows that they have HIV [False]	0.66	0.44
8: When using condoms during sex it is safer to use water-based lubricants than oil-based lubricants [True]	0.43	0.19

9: Only the receptive/"bottom" partner is at risk of being infected with HIV during anal sex [False]	0.67	0.44
10: There is a medication you can take after being exposed to HIV that reduces your risk of contracting HIV [True]	0.40	0.16
11: Taking pre-exposure prophylaxis (a pill, also known as PrEP or Truvada) regularly can reduce the risk of contracting HIV from an HIV-positive sex partner [True]	0.52	0.27
Behavioral skills		
1: How confident are you that you would be able to attend these doctor appointments [for PrEP care] every three months?	0.40	0.16
2: How confident are you that you could get pre-exposure prophylaxis (PrEP) where you live?	0.76	0.58
3: Imagine you were interested in starting PrEP. Do you know of a doctor or medical provider that would prescribe PrEP to you?	0.73	0.53

CFA (confirmatory factor analysis); PrEP (pre-exposure prophylaxis).
Items in italics were removed in scale revision.
Model fit: $\chi^2(50) = 124.37$, $p = 0.000$; RMSEA = 0.03 [90% CI = 0.03-0.04]; CFI = 0.96; TLI = 0.95.

Structural model: Willingness to use PrEP. An unadjusted structural model testing associations between information, motivation, behavioral skills, and willingness to use PrEP had good fit ($\chi^2(79) = 230.93$, p = 0.000; RMSEA = 0.04 [90% CI 0.03-0.04]; CFI = 0.94; TLI = 0.92). Unadjusted direct effects are displayed in Table 3.5. Indirect effects are displayed in Table 3.6.

Standardized results from the unadjusted model showed that information had a direct and positive association with behavioral skills ($\beta = 0.377$, $p = 0.000$), personal motivation had a direct and positive association with willingness to use PrEP ($\beta = 0.090$, $p = 0.015$), social motivation had a direct and positive association with behavioral skills ($\beta = 0.489$, $p = 0.000$), and behavioral skills had a direct and positive association with willingness to use PrEP ($\beta = 0.248$, $p = 0.001$). There was a significant indirect effect from information to willingness to use PrEP via behavioral skills ($\beta = 0.093$, 95% CI 0.017-0.170), and a significant indirect effect from social motivation to willingness to use PrEP via behavioral skills ($\beta = 0.121$, 95% CI 0.021-0.222). The indirect effect from personal motivation to willingness to use PrEP via behavioral skills was not significant.

Table 3.5. Direct effects from structural equation model testing associations between PrEP-related information, motivation, behavioral skills, and willingness to use PrEP among ASMM (N=1364)

	Unadjusted model		Adjusted model[a]	
	b (SE)	*β* (SE)	*b* (SE)	*β* (SE)
Direct effects				
Information → Behavioral skills	0.336 (0.047)***	0.377 (0.045)***	0.274 (0.046)***	0.318 (0.048)***
Information → Willingness to use PrEP	0.121 (0.086)	0.083 (0.059)	0.080 (0.086)	0.054 (0.058)
Personal motivation → Behavioral skills	-0.020 (0.020)	-0.034 (0.035)	-0.017 (0.019)	-0.030 (0.034)
Personal motivation → Willingness to use PrEP	0.086 (0.035)*	0.090 (0.037)*	0.074 (0.035)*	0.077 (0.036)*
Social motivation → Behavioral skills	0.297 (0.022)***	0.489 (0.034)***	0.256 (0.021)***	0.444 (0.035)***
Social motivation → Willingness to use PrEP	0.008 (0.054)	0.008 (0.054)	-0.013 (0.054)	-0.013 (0.054)
Behavioral skills → Willingness to use PrEP	0.404 (0.129)**	0.248 (0.076)**	0.404 (0.146)**	0.235 (0.083)**
Variable correlations				
Information <> Personal motivation	-0.034 (0.024)	-0.047 (0.034)	-0.034 (0.024)	-0.048 (0.034)
Information <> Social motivation	0.021 (0.025)	0.030 (0.035)	-0.021 (0.024)	-0.030 (0.035)
Personal motivation <> Social motivation	0.025 (0.029)	0.024 (0.027)	0.025 (0.029)	0.024 (0.027)

ASMM (adolescent sexual minority males), PrEP (pre-exposure prophylaxis). *b* = unstandardized parameter estimate; SE = standard error; *β* = standardized parameter estimate.

[a]Adjusted for age, sexual identity, outness, and race/ethnicity.

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Table 3.6. Indirect effects from structural equation model testing associations between PrEP-related information, motivation, behavioral skills, and willingness to use PrEP among ASMM (N=1364)

	Unadjusted model		Adjusted model[a]	
	b (95% CI)	*β* (95% CI)	*b* (95% CI)	*β* (95% CI)
Information				
Direct effect on willingness	0.121 (-0.061-0.302)	0.083 (-0.041-0.207)	0.080 (-0.100-0.259)	0.054 (-0.067-0.174)
Indirect effect on willingness via behavioral skills	**0.136 (0.021-0.251)**	**0.093 (0.017-0.170)**	**0.111 (0.009-0.213)**	**0.075 (0.008-0.141)**
Total effect on willingness	**0.256 (0.112-0.400)**	**0.176 (0.082-0.271)**	**0.190 (0.044-0.337)**	**0.128 (0.032-0.225)**
Personal motivation				
Direct effect on willingness	**0.086 (0.019-0.153)**	**0.090 (0.020-0.160)**	**0.074 (0.008-0.140)**	**0.077 (0.008-0.147)**
Indirect effect on willingness via behavioral skills	-0.008 (-0.027-0.011)	-0.008 (-0.028-0.011)	-0.007 (-0.025-0.011)	-0.007 (-0.026-0.012)
Total effect on willingness	**0.078 (0.012-0.144)**	**0.081 (0.012-0.150)**	**0.067 (0.002-0.132)**	**0.070 (0.003-0.138)**
Social motivation				
Direct effect on willingness	0.008 (-0.109-0.125)	0.008 (-0.110-0.126)	-0.013 (-0.127-0.100)	-0.013 (-0.128-0.101)
Indirect effect on willingness via behavioral skills	**0.120 (0.020-0.220)**	**0.121 (0.021-0.222)**	**0.104 (0.013-0.194)**	**0.104 (0.013-0.196)**
Total effect on willingness	**0.128 (0.059-0.197)**	**0.129 (0.059-0.199)**	**0.090 (0.018-0.162)**	**0.091 (0.018-0.164)**

ASMM (adolescent sexual minority males), PrEP (pre-exposure prophylaxis). *b* = unstandardized parameter estimate; CI = confidence interval; *β* = standardized parameter estimate. 95% confidence intervals were calculated using bootstrapping with 1000 iterations and are significant if they do not include zero (bolded).
[a]Adjusted for age, sexual identity, outness, and race/ethnicity.

Age, sexual identity, outness, race/ethnicity, employment status, and living with parents were associated with willingness to use PrEP in bivariate analysis and were entered into the model as covariates. The adjusted model had good fit based on RMSEA = 0.03 (90% CI 0.03-0.04) and CFI = 0.90, but slightly less than acceptable fit based on TLI = 0.86. Living with parents and employment status were not associated with willingness to use PrEP in the multivariable SEM and were dropped from the model. The re-specified model had good fit ($\chi^2(119) = 342.54$, $p = 0.000$; RMSEA = 0.04 [90% CI 0.03-0.04]; CFI = 0.92), though the TLI was still slightly less than acceptable at 0.89. Model residuals were inspected and modification indices were reviewed, however the model could not be further improved. Therefore, this model was accepted on the basis of overall fit, with two of three fit indices suggesting good fit and the TLI only marginally less than acceptable. Adjusted direct effects are displayed in Table 3.5 and Figure 3.2. Indirect effects are displayed in Table 3.6.

Standardized results from the adjusted model showed that there was a direct and positive association between information and behavioral skills ($\beta = 0.318$, $p = 0.000$), a direct and positive association between personal motivation and willingness to use PrEP ($\beta = 0.077$, $p = 0.033$), a direct and positive association between social motivation and behavioral skills ($\beta = 0.444$, $p = 0.000$), and a direct and positive association between behavioral skills and willingness to use PrEP ($\beta = 0.235$, $p = 0.004$). The indirect effects from information to willingness to use PrEP via behavioral skills ($\beta = 0.075$, 95% CI 0.008-0.141) and from social motivation to willingness to use PrEP via behavioral skills ($\beta = 0.104$, 95% CI 0.013-0.196) remained significant. The indirect effect from personal motivation to willingness to use PrEP via behavioral skills remained non-significant.

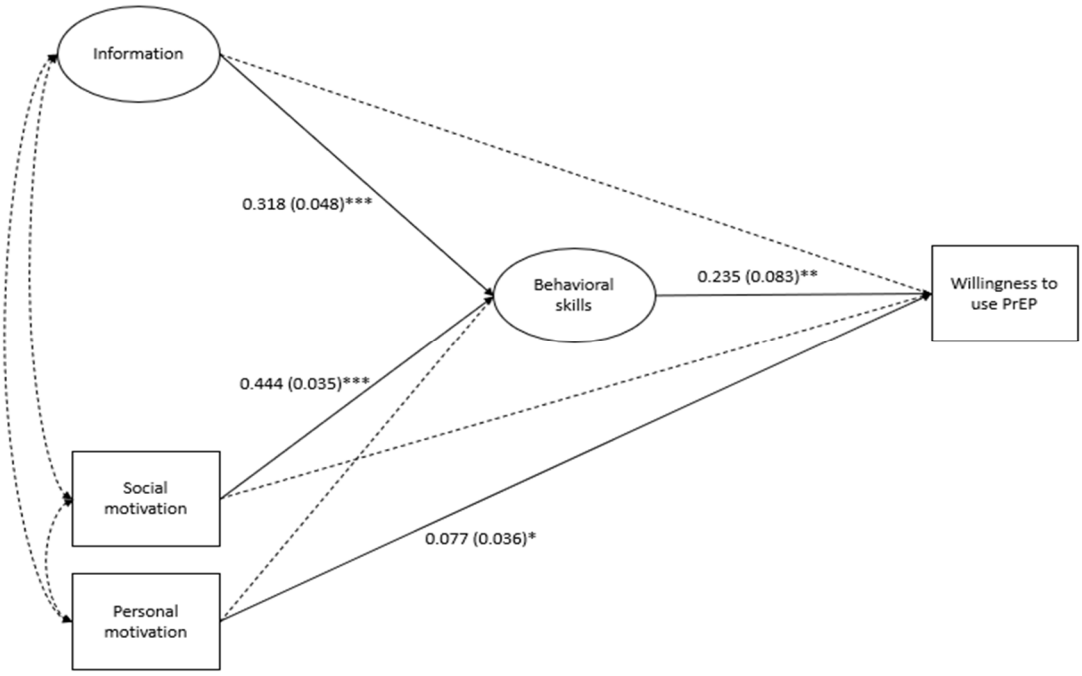

Figure 3.2. Structural equation model testing the associations between PrEP-related information, motivation, behavioral skills, and willingness to use PrEP among ASMM (N=1364). Significant standardized path coefficients are presented. Latent factor loadings are not shown. Adjusted for age, sexual identity, outness, and race/ethnicity. Model fit: $\chi^2(119) = 342.54$, $p = 0.000$; RMSEA = 0.04 (90% CI 0.03-0.04); CFI = 0.92; TLI = 0.89.*p <0.05, **p < 0.01, ***p < 0.001.

Structural model: Intention to use PrEP. An unadjusted structural model testing the associations between information, motivation, behavioral skills, and intention to use PrEP had good fit ($\chi^2(79) = 202.86$, $p = 0.000$; RMSEA = 0.03 [90% CI 0.03-0.04]; CFI = 0.95; TLI = 0.93). Unadjusted direct effects are displayed in Table 3.7. Indirect effects are displayed in Table 3.8.

Table 3.7. Direct effects from structural equation model testing associations between PrEP-related information, motivation, behavioral skills, and intention to use PrEP among ASMM (N=1364)

	Unadjusted model		Adjusted model[a]	
	b (SE)	*β* (SE)	*b* (SE)	*β* (SE)
Direct effects				
Information → Behavioral skills	0.345 (0.048)***	0.375 (0.045)***	0.287 (0.047)***	0.327 (0.048)***
Information → Intention to use PrEP	-0.036 (0.092)	-0.024 (0.063)	-0.069 (0.097)	-0.047 (0.065)
Personal motivation → Behavioral skills	-0.021 (0.021)	-0.035 (0.034)	-0.020 (0.019)	-0.035 (0.034)
Personal motivation → Intention to use PrEP	0.144 (0.036)***	0.151 (0.037)***	0.142 (0.036)***	0.148 (0.038)***
Social motivation → Behavioral skills	0.303 (0.022)***	0.482 (0.034)***	0.263 (0.021)***	0.450 (0.035)***
Social motivation → Intention to use PrEP	-0.036 (0.054)	-0.036 (0.054)	-0.068 (0.056)	-0.069 (0.056)
Behavioral skills → Intention to use PrEP	0.664 (0.139)***	0.420 (0.078)***	0.724 (0.160)***	0.428 (0.087)***
Variable correlations				
Information <> Personal motivation	-0.034 (0.024)	-0.047 (0.034)	-0.034 (0.024)	-0.048 (0.034)
Information <> Social motivation	0.021 (0.025)	0.030 (0.035)	0.021 (0.024)	0.030 (0.035)
Personal motivation <> Social motivation	0.025 (0.029)	0.024 (0.027)	0.025 (0.029)	0.024 (0.027)

ASMM (adolescent sexual minority males), PrEP (pre-exposure prophylaxis). *b* = unstandardized parameter estimate; SE = standard error; *β* = standardized parameter estimate.

[a]Adjusted for age, sexual identity, and outness.

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Standardized results from the unadjusted model showed that information had a direct and positive association with behavioral skills ($\beta = 0.375$, $p = 0.000$), personal motivation had a direct and positive association with intention to use PrEP ($\beta = 0.151$, $p = 0.000$), social motivation had a direct and positive association with behavioral skills ($\beta = 0.482$, $p = 0.000$), and behavioral skills had a direct and positive association with intention to use PrEP ($\beta = 0.420$, $p = 0.000$). There was a significant indirect effect from information to intention to use PrEP via behavioral skills ($\beta = 0.158$, 95% CI 0.075-0.240) and a significant indirect effect from social motivation to intention to use PrEP via behavioral skills ($\beta = 0.203$, 95% CI 0.102-0.304). The indirect effect from personal motivation to intention to use PrEP via behavioral skills was not significant.

Age, sexual identity, and outness were associated with intention to use PrEP in bivariate analysis and were entered into the model as covariates. The adjusted model fit the data well ($\chi^2(109) = 296.43$, $p = 0.000$; RMSEA = 0.04 [90% CI = 0.03-0.04]; CFI = 0.93; TLI = 0.91). Adjusted direct effects are displayed in Table 7 and Figure 3.3. Indirect effects are displayed in Table 8.

Standardized results from the adjusted model showed that information had a direct and positive association with behavioral skills ($\beta = 0.327$, $p = 0.000$), personal motivation had a direct and positive association with intention to use PrEP ($\beta = 0.148$, $p = 0.000$), social motivation had a direct and positive association with behavioral skills ($\beta = 0.450$, $p = 0.000$), and behavioral skills had a direct and positive association with intention to use PrEP ($\beta = 0.428$, $p = 0.000$). The indirect effects from information to intention to use PrEP via behavioral skills ($\beta = 0.140$, 95% CI 0.059-0.221) and from social motivation to intention to use PrEP via behavioral skills ($\beta = 0.192$, 95% CI 0.093-

0.292) remained significant. The indirect effect from personal motivation to intention to use PrEP via behavioral skills remained non-significant.

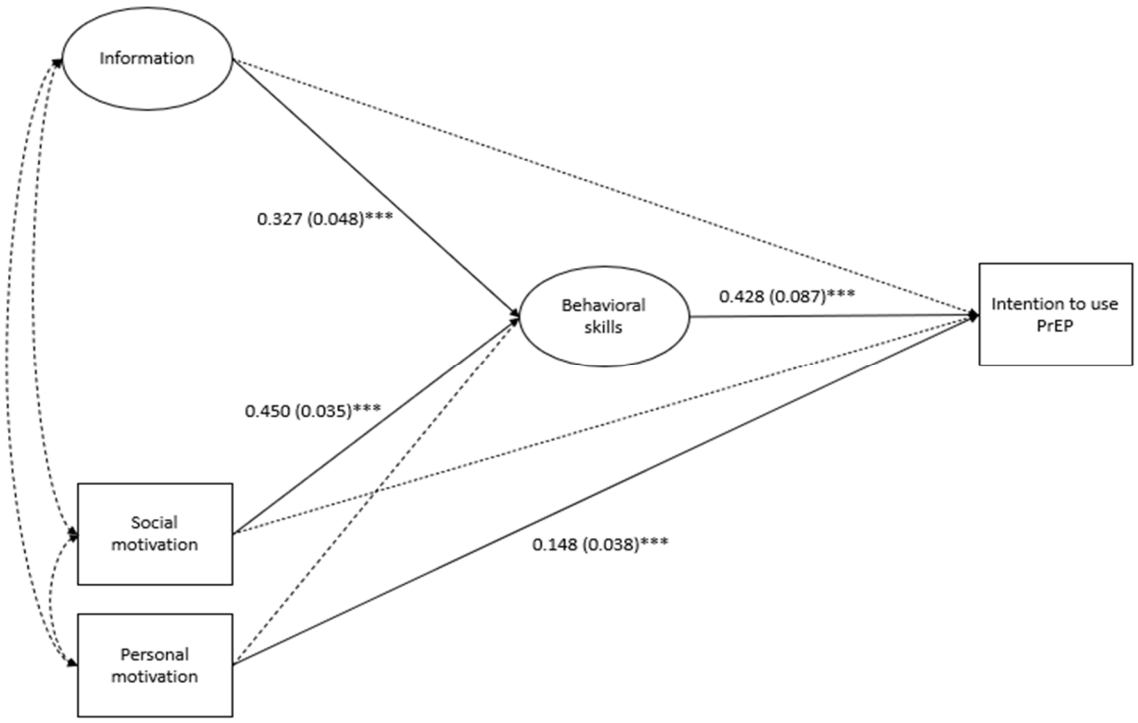

Figure 3.3. Structural equation model testing the associations between PrEP-related information, motivation, behavioral skills, and intention to use PrEP among ASMM (N=1364). Significant standardized path coefficients are presented. Latent factor loadings are not shown. Adjusted for age, sexual identity, and outness. Model fit: $\chi^2(109) = 296.43$, $p = 0.000$; RMSEA = 0.04 [90% CI = 0.03-0.04]; CFI = 0.93; TLI = 0.91. ***$p < 0.001$.

Table 3.8. Indirect effects from structural equation model testing associations between PrEP-related information, motivation, behavioral skills, and intention to use PrEP among ASMM (N=1364)

	Unadjusted model		Adjusted model[a]	
	b (95% CI)	*β* (95% CI)	*b* (95% CI)	*β* (95% CI)
Information				
Direct effect on intention	-0.036 (-0.226-0.155)	-0.024 (-0.155-0.106)	-0.069 (-0.269-0.131)	-0.047 (-0.180-0.087)
Indirect effect on intention via behavioral skills	**0.229 (0.103-0.356)**	**0.158 (0.075-0.240)**	**0.208 (0.081-0.334)**	**0.140 (0.059-0.221)**
Total effect on intention	**0.194 (0.045-0.342)**	**0.133 (0.035-0.231)**	0.139 (-0.017-0.294)	0.093 (-0.008-0.195)
Personal motivation				
Direct effect on intention	**0.144 (0.072-0.216)**	**0.151 (0.075-0.226)**	**0.142 (0.069-0.214)**	**0.148 (0.072-0.224)**
Indirect effect on intention via behavioral skills	-0.014 (-0.043-0.015)	-0.015 (-0.045-0.016)	-0.014 (-0.044-0.016)	-0.015 (-0.046-0.017)
Total effect on intention	**0.130 (0.058-0.202)**	**0.136 (0.061-0.211)**	**0.127 (0.056-0.199)**	**0.133 (0.059-0.208)**
Social motivation				
Direct effect on	-0.036 (-0.153-0.080)	-0.036 (-0.154-0.081)	-0.068 (-0.187-0.051)	-0.069 (-0.188-0.051)
Indirect effect on via behavioral skills	**0.201 (0.102-0.301)**	**0.203 (0.102-0.304)**	**0.191 (0.092-0.289)**	**0.192 (0.093-0.292)**
Total effect on intention	**0.165 (0.098-0.232)**	**0.166 (0.099-0.234)**	**0.123 (0.053-0.193)**	**0.124 (0.053-0.194)**

ASMM (adolescent sexual minority males), PrEP (pre-exposure prophylaxis). *b* = unstandardized parameter estimate; CI = confidence interval; *β* = standardized parameter estimate. 95% confidence intervals were calculated using bootstrapping with 1000 iterations and are significant if they do not include zero (bolded).
[a]Adjusted for age, sexual identity, and outness.

Aim 2 results

Measurement invariance testing: Depression. A separately estimated measurement model for the latent information and behavioral skills factors among participants without depressive symptoms had good model fit ($\chi^2(49) = 93.77$, $p = 0.000$; RMSEA = 0.04 [90% CI 0.02-0.05]; CFI = 0.96; TLI = 0.94). Model fit among participants with depressive symptoms was similar ($\chi^2(49) = 84.10$, $p = 0.000$; RMSEA = 0.04 [90% CI 0.02-0.05]; CFI = 0.96; TLI = 0.95). Multigroup analysis was performed to analyze the separate measurement models simultaneously. The configural model was tested first, with factor loadings and intercepts allowed to differ between participants with and without depressive symptoms. Model fit was acceptable ($\chi^2(107) = 220.98$, $p = 0.000$; RMSEA = 0.04 [90% CI 0.03-0.05); CFI = 0.94; TLI = 0.93). The scalar model was tested with factor loadings and intercepts constrained to equality across groups. Model fit was good based on all indices ($\chi^2(128) = 216.60$, $p = 0.000$; RMSEA = 0.03, [90% CI 0.02-0.04]; CFI = 0.96; TLI = 0.96). The chi-square test for difference testing was not significant ($\chi^2(21) = 5.76$, $p = 0.10$). The scalar model was selected as the best-fitting model. This suggests that the measurement model was invariant when stratifying the sample by presence or absence of depressive symptoms.

Depression and willingness to use PrEP. A structural model examining associations between information, motivation, behavioral skills, and willingness to use PrEP was tested using multigroup analysis to investigate moderation by depression status. First, an unadjusted, unconstrained model was tested. This model had good overall fit ($\chi^2(175) = 329.90$, $p = 0.000$; RMSEA = 0.04 [90% CI 0.03-0.04]; CFI = 0.93; TLI = 0.92). Next, an unadjusted constrained model was tested, with all parameters forced to be

equal across groups. The constrained model also had good overall fit ($\chi^2(185) = 330.15$, $p = 0.000$; RMSEA = 0.03 [90% CI 0.03-0.04]; CFI = 0.94; TLI = 0.93). Constraining all paths to equality did not degrade model fit ($\chi^2(10) = 11.71$, $p = 0.305$). Inspection of individual parameters did not suggest any meaningful differences between groups. The constrained model was accepted as the best-fitting model, indicating that depression did not moderate the associations between information, motivation, behavioral skills, and willingness to use PrEP. The constrained model was then adjusted for the same covariates used in the aggregate model of willingness to use PrEP (age, sexual identity, outness, and race/ethnicity), with the same error covariances as in the aggregate model, and had good overall fit ($\chi^2(265) = 482.73$, $p = 0.000$; RMSEA = 0.04 [90% CI 0.03-0.04]; CFI = 0.92; TLI = 0.89).

Depression and intention to use PrEP. A structural model examining associations between information, motivation, behavioral skills, and intention to use PrEP was tested using multigroup analysis to investigate moderation by depression status. An unadjusted unconstrained model fit the data well ($\chi^2(175) = 309.10$, $p = 0.000$; RMSEA = 0.03 [90% CI 0.03-0.04]; CFI = 0.94; TLI = 0.93). An unadjusted constrained model also fit the data well ($\chi^2(185) = 315.02$, $p = 0.000$; RMSEA = 0.03 [90% CI 0.03-0.04]; CFI = 0.94; TLI = 0.94). Constraining all paths to equality did not degrade model fit ($\chi^2(10) = 13.87$, $p = 0.179$). Inspection of individual parameters did not suggest any meaningful differences between groups. The constrained model was accepted as the best-fitting model, indicating that depression did not moderate associations between information, motivation, behavioral skills, and intention to use PrEP. The constrained model was then adjusted for the same covariates used in the aggregate model of intention to use PrEP

(age, sexual identity, and outness), with the same error covariances as in the aggregate model, and had good model fit ($\chi^2(245) = 439.62$, $p = 0.000$; RMSEA = 0.03 [90% CI 0.03-0.04]; CFI = 0.93; TLI = 0.91).

Measurement invariance testing: Problematic substance use. A separately estimated measurement model for the latent information and behavioral skills factors among participants without problematic substance use had good fit ($\chi^2(49) = 124.52$, $p = 0.000$; RMSEA = 0.04 (90% CI 0.03-0.05); CFI = 0.96; TLI = 0.94). Fit was similar among participants with problematic substance use ($\chi^2(49) = 66.39$, $p = 0.05$; RMSEA = 0.04 [90% CI 0.00-0.06]; CFI = 0.95; TLI = 0.93). Multigroup analysis was performed to analyze the separate measurement models simultaneously. The configural model was tested first, with factor loadings and intercepts allowed to differ between participants with and without problematic substance use. Model fit was good ($\chi^2(107) = 256.53$, $p = 0.000$; RMSEA = 0.05 [90% CI 0.04-0.05]; CFI = 0.92; TLI = 0.91). The scalar model was tested, with factor loadings and intercepts constrained to equality across groups. The chi-square test of the difference between the configural model and the scalar model was not significant ($\chi^2(22) = 28.65$, $p = 0.15$). The scalar model was accepted as the best-fitting model ($\chi^2(129) = 264.02$, $p = 0.000$; RMSEA = 0.04; [90% CI 0.03-0.05]; CFI = 0.93; TLI = 0.93). This suggests that the measurement model was invariant when stratifying the sample by the presence or absence of problematic substance use.

Problematic substance use and willingness to use PrEP. A structural model examining associations between information, motivation, behavioral skills, and willingness to use PrEP was tested using multigroup analysis to investigate moderation by problematic substance use status. An unadjusted unconstrained model fit the data well

($\chi^2(175) = 333.14$, $p = 0.000$; RMSEA = 0.04 [90% CI 0.03-0.04]; CFI = 0.93; TLI = 0.91). An unadjusted constrained model also fit the data well ($\chi^2(185) = 329.89$, $p = 0.000$; RMSEA = 0.03 [90% CI 0.03-0.04]; CFI = 0.93; TLI = 0.92). Constraining all paths to equality did not degrade model fit ($\chi^2(10) = 11.80$, $p = 0.298$).

However, inspection of individual parameters suggested possible differences between groups in the association between behavioral skills and willingness to use PrEP, such that the standardized parameter estimate was positive and highly significant among participants without problematic substance use ($\beta = 0.249$, $p = 0.001$), but negative and highly non-significant among participants with problematic substance use ($\beta = -0.140$, $p = 0.696$). Because this difference was consistent with the pre-specified hypotheses, a post-hoc exploration was performed. A partially constrained model was specified with all paths held equal with the exception of the path between behavioral skills and willingness to use PrEP, which was freely estimated. The partially constrained model fit the data well ($\chi^2(184) = 332.23$, $p = 0.000$; RMSEA = 0.03 [90% CI 0.03-0.04]; CFI = 0.93; TLI = 0.92). The chi-square difference test comparing the fully constrained model to the partially constrained model was not significant ($\chi^2(1) = 0.09$, $p = 0.771$), indicating that constraining the path between behavioral skills and willingness to use PrEP to be equal across groups did not degrade model fit. Therefore, the fully constrained model was accepted as the final model. The constrained model was then adjusted for the same covariates used in the aggregate model of willingness to use PrEP (age, sexual identity, outness, and race/ethnicity), with the same error correlations as in the aggregate model, and had good overall fit ($\chi^2(265) = 470.04$, $p = 0.000$; RMSEA = 0.03 [90% CI 0.03-0.04]; CFI = 0.91; TLI = 0.89).

Problematic substance use and intention to use PrEP. A structural model examining associations between information, motivation, behavioral skills, and intention to use PrEP was tested using multigroup analysis to investigate moderation by problematic substance use status. An unadjusted unconstrained model fit the data well ($\chi^2(175) = 311.06$, $p = 0.000$; RMSEA = 0.03 [90% CI 0.03-0.04]; CFI = 0.94; TLI = 0.92). An unadjusted constrained model also fit the data well ($\chi^2(185) = 312.46$, $p = 0.000$; RMSEA = 0.03 [90% CI 0.03-0.04]; CFI = 0.94; TLI = 0.93). Constraining all paths to equality did not degrade model fit ($\chi^2(10) = 12.72$, $p = 0.240$). Inspection of individual parameters did not suggest any meaningful differences between groups. The fully constrained model was accepted as the best-fitting model, indicating that problematic substance use did not moderate the associations between information, motivation, behavioral skills, and intention to use PrEP. The constrained model was adjusted for the same covariates used in the aggregate model of intention to use PrEP (age, sexual identity, and outness), with the same error covariances as in the aggregate model, and had good model fit ($\chi^2(245) = 423.32$, $p = 0.000$; RMSEA = 0.03 [90% CI 0.03-0.04]; CFI = 0.93; TLI = 0.91).

Sensitivity analysis. Restricting the sample to participants who had ever had anal sex with a male partner did not substantially change the direction or magnitude of the parameter estimates (see Table S3.1 and Table S3.2 in the Appendix).

Discussion

This study was the first to test an IMB model of willingness and intention to use PrEP among ASMM ages 13-18 and the first to investigate moderation of this model by psychosocial health problems that disproportionately affect ASMM. We found support

for most of the IMB model's main hypotheses, consistent with previous empirical tests of IMB models of PrEP uptake in different populations (Shrestha et al., 2017; Walsh, 2019). Participants who were more informed about HIV and PrEP and who had more social motivation to use PrEP had stronger behavioral skills for PrEP uptake. In turn, participants who had stronger behavioral skills were more likely to be willing to use PrEP and were also more likely to have an intention to use PrEP. These results suggest that, among ASMM, the IMB model is an accurate theory of willingness and intention to use PrEP, which are important precursors of PrEP adoption (Kelley et al., 2015; Rendina et al., 2017).

In accordance with the IMB model, we hypothesized that both perceived vulnerability to HIV (i.e., personal motivation) and perceived support from parents (i.e., social motivation), would have indirect associations with willingness and intention to use PrEP. Both of these measures were indeed associated with PrEP willingness and intention. However, we found that these two measures had different relationships with the outcomes of interest. On the one hand, social motivation was indirectly associated with willingness and intention to use PrEP via behavioral skills, as hypothesized. In other words, participants who believed that their parents would be more supportive of their PrEP use were more likely to report confidence in attending PrEP appointments, confidence in getting PrEP, and knowing a provider who could prescribe PrEP. As a result, they were more likely to report willingness and intention to use PrEP. There were no direct associations between perceived support from parents and willingness or intention to use PrEP. On the other hand, personal motivation had no association with behavioral skills and was instead directly associated with willingness and intention to use

PrEP, contrary to our hypothesis. Personal motivation, in this case, perceived vulnerability to HIV, appears to increase willingness and intention to use PrEP regardless of one's level of PrEP-related behavioral skills.

This is a novel finding, as previous studies that tested IMB models of PrEP uptake either did not distinguish between personal motivation and social motivation (Shrestha et al., 2017) or did not include HIV risk perception in their measure of motivation (Walsh, 2019). The association between perceived support from parents and behavioral skills, and the lack of an association between perceived vulnerability to HIV and behavioral skills, may have implications for PrEP initiation among ASMM. It seems likely that ASMM would have difficulty accessing PrEP without first knowing a provider who would prescribe it, even if they believe that they are at risk for HIV and as a result are willing or intending to use it. Therefore, while both perceived parental support and perceived HIV risk are associated with greater willingness and intention to use PrEP, it is possible that support from parents may be a stronger predictor of actual PrEP initiation among ASMM than risk perception alone. Future studies should assess this hypothesis using data on PrEP adoption among ASMM.

Additionally, the direct associations between behavioral skills and willingness and intention to use PrEP were generally stronger than the direct associations between perceived vulnerability to HIV and willingness and intention to use PrEP. This overall pattern of results is consistent with previous findings that individuals who adopt PrEP have significantly higher perceived HIV risk and higher self-efficacy than individuals who do not adopt PrEP, that perceived HIV risk is not correlated with self-efficacy, and that the association between self-efficacy and PrEP adoption is stronger than the

association between perceived HIV risk and PrEP adoption (Golub et al., 2019). Interventions should focus both on increasing HIV risk perception and on building behavioral skills to increase PrEP uptake among ASMM. Furthermore, the association between behavioral skills and intention to use PrEP was stronger than the association between behavioral skills and willingness to use PrEP, suggesting that behavioral skills increase in importance as ASMM get closer to PrEP adoption.

In bivariate analysis, participants with depressive symptoms or problematic substance use were as likely or more likely to be willing or intending to use PrEP compared to their counterparts without depressive symptoms or problematic substance use. This is consistent with a recent systematic review showing that SMM who use substances are as or more likely to take PrEP than are SMM who do not use substances (Viamonte et al., 2022). Furthermore, this study is the first to show that the IMB model's hypotheses remain accurate in the presence of depressive symptoms and problematic substance use. This indicates that IMB-based interventions to increase willingness and intention to use PrEP among ASMM may be successful even in the presence of these psychosocial health problems. However, further study is warranted given that this was the first study to examine psychosocial health problems as moderators of an IMB model of PrEP willingness and intention among ASMM, and that this finding contrasts with previous research in which psychosocial health problems were found to moderate the IMB model in the context of different outcomes and populations.

For example, our final model of willingness to use PrEP did not vary among participants with and without problematic substance use. It should be noted, however, that post-hoc exploration was indicative of a possible difference in the association

between behavioral skills and willingness to use PrEP that should be investigated in future studies. When this path was allowed to be freely estimated, it was significant among participants without problematic substance use but not among participants with problematic substance use. If substantiated in future studies, this could suggest that the behavioral skills that are associated with increased willingness to use PrEP among ASMM without problematic substance use may be inadequate for ASMM with problematic substance use, for whom a different set of behavioral skills may be necessary. Even if ASMM with problematic substance use know where they could get PrEP and are confident in their ability to attend PrEP care appointments, they may have a fear of disclosing their substance use behaviors to their provider, particularly due to concerns about confidentiality (Oldfield & Edelman, 2021), or they may believe that their substance use would affect their ability to take PrEP (Kalichman & Eaton, 2017; Oldenburg et al., 2016). Alternatively, ASMM with problematic substance use may not need behavioral skills at all in order to be willing to use PrEP. Personal motivation in the form of perceived vulnerability to HIV alone may be sufficient to explain willingness to use PrEP because substance use is a known risk factor for HIV sexual risk behavior (Ritchwood et al., 2015). Again, this requires replication, as the fully constrained and partially constrained models in our study were not significantly different.

Additionally, we did not find a difference in the IMB model of willingness or intention to use PrEP among participants with and without depressive symptoms. Because this was the first study to test the hypothesis that depression moderates the IMB model of PrEP uptake, there is no directly comparable evidence in the published literature. Our finding is generally consistent with evidence from Horvath et al. (2014),

where depressive symptoms did not moderate associations between IMB model constructs and ART adherence among adult SMM living with HIV. It is inconsistent with evidence from Safren et al. (2010), where depressive symptoms did moderate associations between social cognitive constructs and condomless sex among adult SMM living with HIV. These studies were focused on very different study populations and outcomes of interest, making them difficult to compare with our study. While our results suggest that an IMB model of PrEP uptake remains robust in the presence of depression, more research is needed to replicate this finding.

It may be that our measure of self-reported depressive symptoms, though based on a clinically meaningful score, included participants whose depression was not severe enough to moderate the IMB model in our study. Following Horvath et al. (2014) and Safren et al. (2010), who also used self-reported measures of depressive symptoms, our study investigated the hypothesis that psychosocial health problems moderate relationships among the IMB model constructs by attenuating their associations with the outcomes of interest. This analytic approach aligns with Dubov et al.'s (2018) theoretical application of the IMB model to PrEP uptake, in which the authors argue that contextual factors such as chemical dependency or psychosocial ill-health make PrEP uptake difficult even for those who are well-informed, motivated, and have behavioral skills.

However, other applications of the IMB model specify that only "extreme" levels of psychosocial health problems make behaviors difficult "regardless of an individual's level of information, motivation, and behavioral skills," while moderate levels of psychosocial health problems influence behavioral outcomes through the IMB model constructs (Fisher et al., 2006). Put another way, whether IMB model constructs are

influenced by or moderated by psychosocial health problems may depend on their severity. As Fisher et al. (2006) state, "lower levels of moderating factors will likely work through the IMB model constructs to influence adherence and not mute relations between IMB model constructs and adherence behavior." Other versions of the IMB model, such as the situated IMB model of care initiation and maintenance, propose that even "extreme" levels of depression and substance use operate through information, motivation, and behavioral skills to influence care utilization (Amico, 2011). Future studies that measure clinical diagnoses of depression and substance use disorders should be conducted to disentangle how psychosocial health problems influence or interact with IMB model constructs in the context of PrEP uptake among ASMM.

We could not examine the psychosocial health problem count variable as a moderator of the IMB model since few participants had co-occurring depressive symptoms and problematic substance use. Larger sample sizes or clinic-based samples may be needed to explore co-occurring depression and substance use as a moderator of the IMB model of PrEP uptake among ASMM, especially given the inconsistent associations between co-occurring psychosocial health problems and PrEP uptake among adult SMM previously reported in the literature (Blashill et al., 2020; Chandler et al., 2020; Sullivan & Eaton, 2021). Our results do show a high burden of the psychosocial health problems that are characterized as a syndemic among SMM. Nearly half of the participants in our sample had symptoms of depression that were considered clinically meaningful, which is similar to the prevalence of depressive symptoms in another nationally representative sample of ASMM (Turpin et al., 2021) and higher than the approximately one-third of heterosexual high school students who reported past-year

symptoms of depression in 2019 (Centers for Disease Control and Prevention, 2020). Problematic substance use was less common, though still prevalent, with 16 percent reporting recent problematic alcohol use, regular marijuana use, or polydrug use. That participants with these psychosocial health problems did not have lower levels of willingness and intention to use PrEP compared to participants without psychosocial health problems is important given that depression and substance use are often associated with HIV sexual risk behavior. However, as noted above, more research is needed to examine these associations using clinical diagnoses of depression and substance use disorders among ASMM.

This study had several limitations. Our findings suggest associations but should not be interpreted causally. Mediation models using cross-sectional data can only present a "possible causal sequence based on plausibility and previous theoretical research" (Bryan et al., 2007). Moreover, our conceptual model assumed that PrEP-related information, motivation, and behavioral skills preceded willingness and intention to use PrEP. In reality, there is likely a feedback loop involved, such that being willing to use PrEP and forming an intention to use PrEP increases information, motivation, and behavioral skills over time (Amico, 2011).

Second, it is possible that construct underrepresentation was a source of measurement error in this analysis. While the SMART program was informed by the IMB model, it was not designed to increase PrEP uptake. Therefore, some of the measures used in this secondary analysis testing an IMB model of PrEP uptake do not completely represent the core IMB model constructs. We did not use previously validated scales to measure PrEP-related information, motivation, or behavioral skills, such as the

PrEP Adherence Self-Efficacy Scale (Golub et al., 2022). The information measure consisted mostly of information about HIV, and our measure of social motivation to use PrEP was limited to perceived social support from parents. Although parents are a very important reference group for ASMM, perceived social support from partners and peers should also be assessed, as well as descriptive and injunctive norms. Further, the three items considered for the personal motivation measure did not load onto a single latent factor, leaving one personal motivation item, a measure of perceived vulnerability to HIV, that had the strongest factor loading. Similarly, we did not assess several aspects of the PrEP behavioral skills construct described by Dubov et al. (2018), such as self-efficacy for managing potential side effects or PrEP stigma, as well as plans to cover costs of care.

Third, because PrEP use was rare in this sample, and because we used cross-sectional data, we examined willingness and intention as outcomes rather than behavior. Any conclusions about PrEP initiation are therefore limited. The existence of a gap between intention and behavior is well-known in the field of health behavior (Sheeran & Webb, 2016) and has also been identified in the context of PrEP uptake (Dai & Harrington, 2021). Willingness and intention to use PrEP are lower threshold outcomes than are complicated behaviors such as PrEP initiation and adherence. Future studies are needed to test the IMB model among ASMM using more advanced stages of the PrEP care continuum as outcomes. For PrEP initiation among ASMM in particular, “external” barriers may limit the utility of an individual-level theory such as the IMB model. Such external barriers include low awareness of and willingness to prescribe PrEP among adolescent healthcare providers and issues related to parental consent and assistance

(Hosek & Henry-Reid, 2020; Huebner & Mustanski, 2020; Pina et al., 2021; Tanner et al., 2020). However, a strength of our study is that we examined intention to use PrEP in addition to willingness to use PrEP. Compared to individuals who are willing to use PrEP but have no intention to do so, individuals who intend to use PrEP are further along in stages of change for PrEP adoption (Rendina et al., 2017).

Finally, although this was a large national sample, the sample may not be representative of the broader population of ASMM in the United States. Participants in this study were recruited for an HIV prevention intervention, which may have implications for many, if not all, of our constructs of interest. For example, ASMM who are interested in participating in and eligible for an HIV prevention intervention may have higher willingness and intention to use PrEP than ASMM who are not interested in participating in an HIV prevention intervention. Future studies using population-based samples are needed to test the IMB model of PrEP uptake among ASMM.

Conclusion

PrEP was only recently approved for adolescents in the U.S., and research on PrEP uptake among ASMM is scarce. This study was one of the first to empirically test a theory-based model of PrEP uptake among ASMM ages 13 to 18. We found that, in general, ASMM who were more informed about PrEP and HIV, and who were more socially motivated to take PrEP, had more PrEP-related behavioral skills. ASMM who had more PrEP-related behavioral skills were more likely to be willing to use PrEP and to have an intention to use PrEP. Additionally, ASMM who were more personally motivated to use PrEP were more likely to be willing to use PrEP and to have an intention to use PrEP. Further, there has been no previous research on psychosocial

health problems as moderators of the IMB model of PrEP uptake among ASMM, despite the early onset of psychosocial health disparities among SMM. Our study suggests that depressive symptoms and problematic substance use do not moderate this model, though further research is needed. These findings support the use of the IMB model in interventions designed to promote PrEP uptake and reduce HIV incidence among ASMM.

Chapter 4: Discussion

Summary of Findings

According to the theory of syndemic production, social adversity in the form of minority stress experienced during adolescence contributes to elevated rates of HIV, depression, and substance use among SMM (Stall et al., 2008). Additionally, the elevated rates of depression and substance use problems characterized as part of a psychosocial syndemic among ASMM may have implications for their engagement in HIV prevention behaviors (Stall et al., 2003). Therefore, this dissertation investigated two research questions: 1) How is HIV sexual risk behavior related to multilevel sexual stigma among ASMM, and 2) How do psychosocial health problems impact PrEP uptake among ASMM?

In Chapter 2, we first examined the relationship between state-level structural stigma and HIV risk among ASMM. We then explored interpersonal stigma, individual stigma, and psychosocial health problems as potential mechanisms linking structural stigma and HIV risk. Although there were no significant direct or indirect associations observed between structural stigma and unprotected anal sex, we did find that participants who lived in states with higher levels of structural stigma were more likely to report experiences of sexual minority victimization. Further, participants who reported more experiences of sexual minority victimization had higher levels of substance use, and participants who had higher levels of substance use were more likely to report unprotected anal sex. This finding extends previous work conducted among adult SMM showing that early-life adverse experiences contribute to syndemic health disparities. First, by examining these associations among ASMM, rather than by using retrospective

reports from adults, our results provide further evidence in support of the theory of syndemic production's developmental hypotheses. Second, our study provides preliminary empirical evidence that sexual stigma at the structural level may contribute to health disparities among ASMM. More research is needed to investigate the latter finding given the lack of a significant indirect effect in our study, despite the presence of a series of significant direct effects between structural stigma, victimization, substance use, and unprotected anal sex.

The second aim of Chapter 2 was to examine differences in these associations by stage of adolescent development. We found that most of the relationships between multilevel sexual stigma, psychosocial health problems, and HIV sexual risk behavior were stable across adolescence, with the exception of a direct association between victimization and unprotected anal sex that was observed only among participants in early adolescence.

In Chapter 3, we investigated whether psychosocial health problems that disproportionately affect ASMM interfere with social cognitive processes involved in PrEP uptake. We first tested an IMB model of willingness and intention to use PrEP among ASMM, with the hypothesis that PrEP-related information, motivation, and behavioral skills would be positively associated with PrEP willingness and intention. We found support for most of the IMB model's hypotheses. Specifically, participants who were more informed about HIV and PrEP, as well as participants who believed that their parents would be more supportive of their PrEP use, were more likely to report confidence in attending PrEP appointments, confidence in getting PrEP, and knowing a provider who could prescribe PrEP. As a result, these participants were more likely to be

willing or intending to use PrEP. However, contrary to the IMB model's hypotheses, perceived vulnerability to HIV, as a measure of personal motivation, was not indirectly related to willingness or intention to use PrEP via behavioral skills, and instead had a direct association with these outcomes.

We next tested the hypothesis that the magnitude of these associations would be attenuated in the presence of depressive symptoms and problematic substance use. Depressive symptoms and problematic substance use did not moderate the associations between IMB model constructs and willingness and intention to use PrEP, suggesting that IMB-based interventions to increase willingness and intention to use PrEP among ASMM may be successful even in the presence of these psychosocial health problems.

However, while we accepted the fully constrained model as our final model, post-hoc exploration signaled a potential difference in the association between behavioral skills and willingness to use PrEP among participants with problematic substance use. Should this difference be replicated in future research, the results from Chapter 2 and Chapter 3 together would provide new insight into the role of substance use in the context of HIV vulnerability among ASMM. Specifically, substance use may compound HIV risk among ASMM by both increasing the likelihood of unprotected anal sex and by creating additional barriers to engagement in HIV prevention methods such as PrEP. Such evidence would support current efforts to prioritize ASMM with problematic substance use for HIV prevention and PrEP programs.

Strengths and Limitations

This dissertation had several strengths. First, we focused on ASMM ages 13 to 18. Due in large part to regulatory barriers, research rarely includes adolescents under the age

of 18 (Mustanski, 2015). Nevertheless, adolescence is a critical period of the life course during which sexual orientation disparities emerge, and these disparities can influence outcomes in adulthood. Second, both chapters analyzed data collected from a large, diverse, national sample of ASMM. This afforded us several advantages, including increased representativeness, increased statistical power, and the ability to perform multigroup analyses, which require large sample sizes. Third, this dissertation was theory-driven. Both studies were informed by the theory of syndemic production, which focuses on the role of the social environment in HIV risk, emphasizes developmental factors that contribute to health disparities among SMM, and is itself informed by minority stress theory. Furthermore, in order to perform a more nuanced investigation of the research questions, each manuscript incorporated additional theories: the multilevel stigma framework in Chapter 2 and the IMB model in Chapter 3.

This dissertation also had several limitations. In both studies, we specified hypotheses about mediation, or in other words, "how" or "why" variables influence each other. Mediation analyses using cross-sectional data are limited given the lack of temporal precedence and the lack of information about change over time. Conclusions cannot be drawn from this dissertation about the causal role of multilevel stigma in HIV sexual risk behavior or the causal role of the IMB model constructs in PrEP uptake. Additionally, although we analyzed data from a large national sample of ASMM, this was not a probability sample, which decreases external validity. Finally, while this dissertation focused on psychosocial health disparities among ASMM, most ASMM do not experience psychosocial health problems, even with exposure to adversity (Herrick et

al., 2014). This dissertation does not contribute to understanding factors that promote resiliency among ASMM affected by multiple sources of sexual stigma.

Directions for Future Research

The results from this dissertation point to the need for future research in several areas. In Chapter 2, we identified the need for research on structural stigma and HIV risk among ASMM to include measures of structural stigma at the city- and school-levels, in addition to the state-level. These more proximate levels of structural stigma may exert a stronger influence on psychosocial health and HIV sexual risk behavior among ASMM. While we adjusted for urban/rural residence, future studies could also examine urbanicity as a moderator of the relationship between structural stigma and HIV risk. Additionally, longitudinal or quasi-experimental data are needed to examine changes in these relationships across adolescence. Future studies on structural stigma and HIV sexual risk behavior among ASMM should consider partner type (i.e., primary or casual partners) and sexual positioning (i.e., insertive or receptive anal sex) in measures of HIV risk, as well as the relationship between structural stigma and other outcomes related to HIV prevention, such as HIV testing and PrEP use. While a strength of this study was that it included three levels of sexual stigma in the same model, it did not consider other types of stigma, such as stigma based on race or ethnicity. Future studies should be conducted to integrate the multilevel stigma and intersectional stigma frameworks. Structural stigma was examined as an independent variable to explore the hypothesis that structural stigma, interpersonal stigma, and individual stigma are part of the same pathway linked to HIV sexual risk behavior. However, structural stigma may also act as a moderator of the

associations between interpersonal or individual stigma and health outcomes (Pachankis et al., 2014), which should be investigated in future studies on HIV risk among ASMM.

In Chapter 3, we identified the need for future research to further examine the association between PrEP-related behavioral skills and willingness to use PrEP among participants with problematic substance use. Additionally, studies that measure clinical diagnoses of depression and substance use disorders should be conducted to disentangle how psychosocial health problems influence or interact with IMB model constructs in the context of PrEP uptake among ASMM. Future research should test the IMB model of PrEP uptake using validated measures of PrEP-related information, motivation, and behavioral skills, as well as actual initiation of PrEP among ASMM as an outcome. Research is also needed to test psychosocial health problems as moderators of an IMB model of PrEP adoption and adherence, which are complicated behaviors and higher threshold outcomes than willingness or intention to use PrEP. Furthermore, larger sample sizes or clinic-based samples are needed to determine whether co-occurring depression and problematic substance use moderates relationships among the IMB model constructs. Finally, future research could investigate these research questions in the context of other PrEP modalities, given the FDA approval of long-acting injectable PrEP for both adults and adolescents in December 2021.

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Appendix

Supplementary Tables: Chapter 2

Table S2.1. State-level structural stigma scores

	State	Structural stigma score
1	Mississippi	5.30
2	Alabama	4.45
3	Oklahoma	4.43
4	South Dakota	4.40
5	North Dakota	4.36
6	Idaho	3.93
7	Wyoming	3.76
8	South Carolina	3.64
9	Arkansas	3.52
10	Montana	3.21
11	Kentucky	3.21
12	Nebraska	3.08
13	Kansas	2.90
14	Louisiana	2.52
15	West Virginia	2.42
16	Utah	2.41
17	Tennessee	2.31
18	Georgia	2.13
19	Alaska	2.03
20	Texas	1.75
21	Michigan	1.65
22	Ohio	1.65
23	Virginia	1.58
24	Missouri	1.55
25	Indiana	1.48
26	North Carolina	0.79
27	Pennsylvania	0.63
28	Arizona	0.47
29	Wisconsin	0.14
30	Iowa	-0.35
31	Illinois	-0.90
32	Florida	-0.91
33	New Mexico	-1.69
34	Minnesota	-1.79
35	Hawaii	-1.93
36	Maryland	-2.61
37	Oregon	-2.82
38	Colorado	-3.34
39	New Jersey	-3.35
40	Nevada	-3.36
41	Washington	-3.87
42	Delaware	-3.90
43	New Hampshire	-3.91
44	Connecticut	-4.08
45	Rhode Island	-4.38
46	California	-4.47
47	Vermont	-4.70
48	Maine	-4.90
49	New York	-4.96
50	Massachusetts	-6.45

Scores were calculated using the density of same-sex couples, percentage of secondary schools with a Gender-Sexuality Alliance or similar club, public policies, and public opinion. Higher scores indicate higher levels of state-level structural stigma.

Table S2.2. Sensitivity analysis comparing unstandardized parameter estimates from the multigroup structural equation model (no age adjustment) and an age-adjusted model among participants in early and middle adolescence

	Early adolescence		Middle adolescence	
	Multigroup model	Age-adjusted model	Multigroup model	Age-adjusted model
Direct effects				
Structural stigma → Microaggression	0.01 (0.02)	-0.01 (0.02)	0.01 (0.02)	-0.01 (0.02)
Structural stigma → Victimization	0.05 (0.06)	0.03 (0.10)	0.05 (0.06)	0.03 (0.10)
Structural stigma → Internalized homophobia[a]	-0.05 (0.04)	-0.04 (0.04)	-0.02 (0.02)	-0.01 (0.02)
Structural stigma → Depression	0.06 (0.11)	-0.11 (0.17)	0.06 (0.11)	-0.11 (0.17)
Structural stigma → Substance use	-0.03 (0.03)	-0.04 (0.04)	-0.03 (0.03)	-0.04 (0.04)
Structural stigma → Unprotected anal sex	-0.02 (0.02)	-0.02 (0.02)	-0.02 (0.02)	-0.02 (0.02)
Microaggression → Internalized homophobia	0.09 (0.02)***	0.07 (0.02)**	0.09 (0.02)***	0.07 (0.02)**
Microaggression → Depression	1.00 (0.20)***	1.09 (0.23)***	1.00 (0.20)***	1.09 (0.23)***
Microaggression → Substance use	0.00 (0.04)	-0.03 (0.04)	0.00 (0.04)	-0.03 (0.04)
Microaggression → Unprotected anal sex	-0.03 (0.04)	-0.03 (0.05)	-0.03 (0.04)	-0.03 (0.05)
Victimization → Internalized homophobia	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)
Victimization → Depression	0.31 (0.07)***	0.23 (0.08)**	0.31 (0.07)***	0.23 (0.08)**
Victimization → Substance use	0.05 (0.02)**	0.04 (0.02)**	0.05 (0.02)**	0.04 (0.02)**
Victimization → Unprotected anal sex[a]	0.07 (0.03)*	0.05 (0.03)	-0.03 (0.02)	-0.03 (0.02)
Internalized homophobia → Depression	2.72 (0.32)***	2.15 (0.39)***	2.72 (0.32)***	2.15 (0.39)***
Internalized homophobia → Substance use	-0.00 (0.05)	-0.07 (0.06)	-0.00 (0.05)	-0.07 (0.06)
Internalized homophobia → Unprotected anal sex	0.01 (0.05)	-0.03 (0.08)	0.01 (0.05)	-0.03 (0.08)
Depression → Unprotected anal sex	-0.00 (0.01)	-0.00 (0.01)	-0.00 (0.01)	-0.00 (0.01)
Substance use → Unprotected anal sex	0.11 (0.04)**	0.14 (0.06)*	0.11 (0.04)**	0.14 (0.06)*
Variable correlations				
Victimization <> Microaggression	0.77 (0.10)***	0.80 (0.14)***	0.77 (0.10)***	0.80 (0.14)***
Depression <> Substance use	0.58 (0.39)	0.30 (0.45)	0.58 (0.39)	0.30 (0.45)

ASMM (adolescent sexual minority males). Early = ages 13-15; Middle = ages 16-17.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
[a] Pathway was freely estimated across groups in unadjusted and adjusted models.

Table S2.3. Sensitivity analysis comparing unstandardized parameter estimates from the multigroup structural equation model and a model adjusted for living situation and student status among participants in late adolescence

	Late adolescence	
	Multigroup SEM model	Model adjusted for living situation and student status
Direct effects		
Structural stigma → Microaggression	0.01 (0.02)	0.04 (0.02)
Structural stigma → Victimization	0.05 (0.06)	0.05 (0.08)
Structural stigma → Internalized homophobia[a]	0.02 (0.02)	0.02 (0.02)
Structural stigma → Depression	0.06 (0.11)	0.13 (0.17)
Structural stigma → Substance use	-0.03 (0.03)	-0.01 (0.05)
Structural stigma → Unprotected anal sex	-0.02 (0.02)	-0.03 (0.03)
Microaggression → Internalized homophobia	0.09 (0.02)***	0.12 (0.04)**
Microaggression → Depression	1.00 (0.20)***	0.77 (0.37)*
Microaggression → Substance use	0.00 (0.04)	0.19 (0.13)
Microaggression → Unprotected anal sex	-0.03 (0.04)	0.00 (0.07)
Victimization → Internalized homophobia	0.01 (0.01)	0.00 (0.01)
Victimization → Depression	0.31 (0.07)***	0.43 (0.10)***
Victimization → Substance use[b]	0.05 (0.02)**	0.08 (0.04)*
Victimization → Unprotected anal sex	-0.01 (0.02)	-0.02 (0.02)
Internalized homophobia → Depression	2.72 (0.32)***	3.97 (0.43)***
Internalized homophobia → Substance use	-0.00 (0.05)	0.09 (0.11)
Internalized homophobia → Unprotected anal sex	0.01 (0.05)	0.03 (0.08)
Depression → Unprotected anal sex	-0.00 (0.01)	0.00 (0.01)
Substance use → Unprotected anal sex	0.11 (0.04)**	0.10 (0.06)
Variable correlations		
Victimization <> Microaggression	0.77 (0.10)***	0.72 (0.14)***
Depression <> Substance use[a]	0.58 (0.39)	1.86 (0.87)*

ASMM (adolescent sexual minority males). Late adolescence = age 18.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Table S2.4. Distribution of key variables in pre-COVID-19 and post-COVID-19 samples

	Pre-COVID-19 (n = 873)	Post-COVID-19 (n = 165)	Test-statistic
	Mean (SD)		
Structural stigma	-0.84 (2.95)	-1.08 (3.10)	0.94
Victimization	1.82 (3.43)	1.80 (3.01)	0.09
Microaggression	2.80 (1.10)	2.73 (0.95)	0.86
Internalized homophobia	2.08 (0.77)	2.24 (0.82)	-2.36*
Depression	57.89 (8.86)	57.30 (9.04)	0.78
Alcohol use	1.71 (2.18)	1.52 (2.02)	1.04
Marijuana use	0.94 (1.30)	1.02 (1.44)	-0.71
	N (%)		
Polydrug use	84 (9.62)	15 (9.09)	0.05
Unprotected anal sex	406 (46.5)	74 (44.9)	0.15

P-value calculated using t-tests and chi-square tests.
*$p < 0.05$.

Table S2.5. Sensitivity analysis comparing adjusted unstandardized parameter estimates from structural equation model of past 3-month unprotected anal sex among all participants and pre-COVID-19 participants

	Full sample (N = 1031)	Pre-COVID-19 sample[a] (N = 866)
Direct effects		
State-level structural stigma → Microaggression	0.019 (0.016)	0.012 (0.016)
State-level structural stigma → Victimization	0.092 (0.041)*	0.089 (0.049)
State-level structural stigma → Internalized homophobia	0.001 (0.011)	-0.004 (0.011)
State-level structural stigma → Depression	0.021 (0.144)	0.165 (0.160)
State-level structural stigma → Substance use	-0.042 (0.030)	-0.040 (0.032)
State-level structural stigma → Unprotected anal sex	-0.020 (0.020)	-0.023 (0.024)
Microaggression → Internalized homophobia	0.094 (0.021)***	0.094 (0.021)***
Microaggression → Depression	0.956 (0.253)***	1.259 (0.238)***
Microaggression → Substance use	0.024 (0.063)	0.050 (0.052)
Microaggression → Unprotected anal sex	-0.031 (0.047)	-0.037 (0.046)
Victimization → Internalized homophobia	0.007 (0.007)	0.010 (0.007)
Victimization → Depression	0.314 (0.066)***	0.261 (0.066)***
Victimization → Substance use	0.053 (0.018)**	0.055 (0.016)**
Victimization → Unprotected anal sex	-0.005 (0.011)	-0.002 (0.013)
Internalized homophobia → Depression	3.004 (0.348)***	2.889 (0.345)***
Internalized homophobia → Substance use	0.058 (0.066)	-0.006 (0.063)
Internalized homophobia → Unprotected anal sex	-0.001 (0.056)	0.047 (0.052)
Depression → Unprotected anal sex	-0.002 (0.004)	-0.003 (0.005)
Substance use → Unprotected anal sex	0.109 (0.032)**	0.106 (0.030)**
Variable correlations		
Victimization <> Microaggression	0.823 (0.118)***	0.946 (0.123)***
Depression <> Substance use	0.943 (0.485)	0.710 (0.516)

[a] Pre-COVID-19 model fit: $\chi^2(46) = 54.76$, $p = 0.18$; RMSEA = 0.02 (90% CI 0.00-0.03), CFI = 0.98, TLI = 0.94.

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Table S2.6. Sensitivity analysis comparing unstandardized adjusted parameter estimates from the multigroup structural equation model in the full sample and the pre-COVID-19 sample

	Early adolescence		Middle adolescence		Late adolescence	
	Full sample (n = 134)	Pre-COVID-19 (n = 119)	Full sample (n = 432)	Pre-COVID-19 (n = 375)	Full sample (n = 465)	Pre-COVID-19 (n = 372)
Direct effects						
SS → MA	0.01 (0.02)	0.01 (0.02)	0.01 (0.02)	0.01 (0.02)	0.01 (0.02)	0.01 (0.02)
SS → VT	0.05 (0.06)	0.03 (0.07)	0.05 (0.06)	0.03 (0.07)	0.05 (0.06)	0.03 (0.07)
SS → IH[a]	-0.05 (0.04)	-0.06 (0.04)	-0.02 (0.02)	-0.00 (0.02)	0.02 (0.02)	0.00 (0.02)
SS → DP	0.06 (0.11)	0.18 (0.14)	0.06 (0.11)	0.18 (0.14)	0.06 (0.11)	0.18 (0.14)
SS → SU	-0.03 (0.03)	-0.01 (0.08)	-0.03 (0.03)	-0.02 (0.03)	-0.03 (0.03)	-0.02 (0.03)
SS → UAS	-0.02 (0.02)	-0.03 (0.02)	-0.02 (0.02)	-0.03 (0.02)	-0.02 (0.02)	-0.03 (0.02)
MA → IH	0.09 (0.02)***	0.08 (0.02)***	0.09 (0.02)***	0.08 (0.02)***	0.09 (0.02)***	0.08 (0.02)***
MA → DP	1.00 (0.20)***	1.31 (0.20)***	1.00 (0.20)***	1.31 (0.20)***	1.00 (0.20)***	1.31 (0.20)***
MA → SU	0.00 (0.04)	0.05 (0.04)	0.00 (0.04)	0.05 (0.04)	0.00 (0.04)	0.05 (0.04)
MA → UAS	-0.03 (0.04)	-0.03 (0.04)	-0.03 (0.04)	-0.03 (0.04)	-0.03 (0.04)	-0.03 (0.04)
VT → IH[b]	0.01 (0.01)	0.03 (0.01)	0.01 (0.01)	-0.01 (0.01)	0.01 (0.01)	0.02 (0.02)
VT → DP	0.31 (0.07)***	0.27 (0.08)**	0.31 (0.07)***	0.27 (0.08)**	0.31 (0.07)***	0.27 (0.08)**
VT → SU[b]	0.05 (0.02)**	0.01 (0.02)	0.05 (0.02)**	0.02 (0.02)	0.05 (0.02)**	0.13 (0.04)**
VT → UAS[a]	0.07 (0.03)*	-0.00 (0.02)	-0.03 (0.02)	-0.00 (0.02)	-0.01 (0.02)	-0.01 (0.02)
IH→ DP	2.72 (0.32)***	2.64 (0.34)***	2.72 (0.32)***	2.64 (0.34)***	2.72 (0.32)***	2.64 (0.34)***
IH → SU	-0.00 (0.05)	-0.07 (0.06)	-0.00 (0.05)	-0.07 (0.06)	-0.00 (0.05)	-0.07 (0.06)
IH → UAS	0.01 (0.05)	0.05 (0.05)	0.01 (0.05)	0.05 (0.05)	0.01 (0.05)	0.05 (0.05)
DP → UAS	-0.00 (0.01)	-0.00 (0.01)	-0.00 (0.01)	-0.00 (0.01)	-0.00 (0.01)	-0.00 (0.01)
SU → UAS	0.11 (0.04)**	0.11 (0.04)**	0.11 (0.04)**	0.11 (0.04)**	0.11 (0.04)**	0.11 (0.04)**
Variable correlations						
VT <> MA	0.77 (0.10)***	0.93 (0.112)***	0.77 (0.10)***	0.93 (0.12)***	0.77 (0.10)***	0.93 (0.12)***
DP <> SU	0.58 (0.39)	0.48 (0.43)	0.58 (0.39)	0.48 (0.43)	0.58 (0.39)	0.48 (0.43)

DP (depression), IH (internalized homophobia), MA (microaggression), SS (structural stigma), SU (substance use), UAS (unprotected anal sex), VT (victimization). Early = ages 13-15; Middle = ages 16-17; Late = age 18.

[a] Pathway was freely estimated across groups in the full sample only.
[b] Pathway was freely estimated across groups in the pre-COVID-19 sample only.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.
Pre-COVID-19 sample model fit: RMSEA = 0.017 (90% CI 0.000-0.034), CFI = 0.973, TLI = 0.934.

Supplementary Tables: Chapter 3

Table S3.1. Sensitivity analysis comparing adjusted unstandardized parameter estimates from structural equation model of willingness to use PrEP among all participants and participants with a history of anal sex with a male partner

	All participants (N = 1364)	Participants with anal sex history (n = 951)
Direct effects		
Information → Behavioral skills	0.27 (0.05)***	0.30 (0.06)***
Information → Willingness to use PrEP	0.08 (0.09)	0.07 (0.12)
Personal motivation → Behavioral skills	-0.02 (0.02)	-0.02 (0.02)
Personal motivation → Willingness to use PrEP	0.07 (0.04)*	0.07 (0.04)
Social motivation → Behavioral skills	0.26 (0.02)***	0.25 (0.03)***
Social motivation → Willingness to use PrEP	-0.01 (0.05)	0.02 (0.07)
Behavioral skills → Willingness to use PrEP	0.40 (0.15)**	0.36 (0.19)
Variable correlations		
Information <> Personal motivation	-0.03 (0.03)	0.00 (0.03)
Information <> Social motivation	0.02 (0.02)	0.02 (0.03)
Personal motivation <> Social motivation	0.03 (0.03)	0.06 (0.04)

PrEP (pre-exposure prophylaxis).
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Table S3.2. Sensitivity analysis comparing adjusted unstandardized parameter estimates from structural equation model of intention to use PrEP among all participants and participants with a history of anal sex with a male partner

	All participants (N = 1364)	Participants with anal sex history (N = 951)
Direct effects		
Information → Behavioral skills	0.29 (0.05)***	0.31 (0.06)***
Information → Intention to use PrEP	-0.07 (0.10)	-0.06 (0.12)
Personal motivation → Behavioral skills	-0.02 (0.02)	-0.02 (0.02)
Personal motivation → Intention to use PrEP	0.14 (0.04)***	0.13 (0.04)**
Social motivation → Behavioral skills	0.26 (0.02)***	0.25 (0.03)***
Social motivation → Intention to use PrEP	-0.07 (0.06)	-0.06 (0.07)
Behavioral skills → Intention to use PrEP	0.72 (0.16)***	0.67 (0.20)**
Variable correlations		
Information <> Personal motivation	-0.03 (0.02)	0.00 (0.03)
Information <> Social motivation	0.02 (0.02)	0.02 (0.03)
Personal motivation <> Social motivation	0.03 (0.03)	0.06 (0.04)

PrEP (pre-exposure prophylaxis).
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.