Published in final edited form as:

AIDS Behav. 2017 March ; 21(3): 845–857. doi:10.1007/s10461-016-1607-3.

Prospective effects of a syndemic on HIV and STI incidence and risk behaviors in a cohort of young men who have sex with men

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Abstract

Young men who have sex with men continue to be highly affected by HIV. To improve understanding of the role that multiple co-occurring health issues (i.e., syndemics) play in HIV acquisition, sophisticated modeling methods are needed. The purpose of this study was to use structural equation modeling to understand the structure of the syndemic and to test its longitudinal association with condomless anal sex. Data are from a longitudinal study of 450 YMSM. A primary syndemic component comprised of substance use, violence, and internalizing mental health factors significantly predicted the number of condomless anal sex partners in the full sample. Analyses exploring associations by race/ethnicity found a significant association among White YMSM, but not among Black or Latino YMSM. Higher-order factor modeling suggests these psychosocial factors form a syndemic in all racial/ethnic groups, but the syndemic, as conceptualized here, may be less relevant to racial/ethnic minority YMSM.

Keywords

YMSM; HIV; syndemic; factor analysis

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Compliance with Ethical Standards:

Conflict of Interest: Brian Mustanski declares that he has no conflict of interest. Gregory Phillips declares that he has no conflict of interest. Daniel Ryan declares that he has no conflict of interest. Gregory Swann declares that he has no conflict of interest. Lisa Kuhns declares that she has no conflict of interest. Rob Garofalo declares that he has no conflict of interest.

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors.

Informed consent: Informed consent was obtained from all individual participants included in the study.

INTRODUCTION

While the annual number of HIV diagnoses has recently decreased among heterosexuals and people who inject drugs, it has increased among men who have sex with men¹. Young men who have sex with men (YMSM) are at the leading edge of this epidemic^{2,3}. Within a sample of YMSM aged 18 to 24 years recruited through the National HIV Behavioral Surveillance (NHBS) System in 21 U.S. cities, annual HIV incidence density was estimated to be 2.9%². Longitudinal cohort studies have produced similarly high estimates, including an annual incidence of 4.11% among YMSM ages 16–20 years at enrollment in Chicago⁴ and 2.85% among New York YMSM ages 18–19 at enrollment⁵. If such high incidence is sustained within a cohort it would yield an HIV prevalence of over 40% by age 40⁶.

Black YMSM are particularly hard hit by the epidemic, with an estimated prevalence among 18–24 year olds of 16.5%, and annual incidence of 5.1%²; other studies suggest the incidence may be higher^{4,7,8}. In fact, the Centers for Disease Control and Prevention (CDC) recently estimated the lifetime risk of HIV diagnosis among MSM to be 50% among Black MSM, 25% among Hispanic MSM, and 9% among White MSM⁹.

Given the alarming disparities in HIV among Black MSM, much of the research to understand the drivers of racial disparities has focused on comparing the risk behaviors of Black and White MSM. In adult MSM, the evidence is clear that Black MSM do not report engaging in more condomless anal sex (CAS), having more partners, or injection drug use than White MSM^{10–15}. Research with YMSM has subsequently shown the same pattern of results^{16–19}. As group differences in engagement in HIV transmission risk behavior cannot explain these disparities, differences in partner and network characteristics have been hypothesized instead^{3,10}.

Research on YMSM has identified the frequent occurrence of psychosocial issues shown to be associated with engagement in high-risk behaviors, such as condomless sex, and acquisition of HIV^{20,21}. Syndemic theory refers to multiple co-occurring adverse conditions that work together to increase negative health outcomes such as HIV. Singer coined the term “syndemic” to describe the intertwined epidemics of substance abuse and violence in understanding the burgeoning HIV epidemic among drug users and the urban poor^{22,23}. Over the past decade, the focus of syndemic research has increasingly been turned toward MSM. In the Urban Men’s Health Study, Stall et al. found interrelationships between drug use, depression, and experiences of violence and victimization among adult MSM²⁴. The number of syndemic conditions was significantly associated with HIV prevalence and CAS. Further cross-sectional studies of adult MSM replicated the association between syndemic factors and HIV status or risk behaviors in North America^{25,26} and other countries^{27–29}. These cross-sectional findings have also been replicated in studies of YMSM^{20,21}. For example, in the first syndemic study among YMSM, Mustanski found interrelationships among substance use, psychological distress, and experiences of violence, with the number of syndemic factors significantly related to CAS and HIV status²⁰. In addition to these core syndemic factors (i.e., depression, substance use, and experiences of violence/victimization), some studies of MSM have included other psychosocial risk factors, such as sexual compulsivity²⁶, tobacco use²⁹, or incarceration³⁰. The inclusion of these additional

psychosocial factors raises an important question about what should and should not be included as part the syndemic construct for applications of the syndemic approach.

In research with YMSM, the original and most consistently included syndemic factors are substance abuse, internalizing mental health problems, and experiences of violence/victimization. The justification for focusing on these syndemic factors is the strong evidence of sexual orientation disparities in their prevalence and their interrelationships³¹. Compared with their heterosexual peers, YMSM are significantly more likely to report the use of illicit drugs³² and alcohol³³. Additionally, internalizing mental health problems such as depression, anxiety, and suicidal ideation or attempts are more prevalent among YMSM than among their heterosexual peers^{34–37}. YMSM experience many forms of physical and verbal violence, including community violence³⁸, parental abuse, sexual abuse³⁹, intimate partner violence (IPV)^{31,40}, and sexual orientation-based victimization^{36,41}. Given the racial disparities in HIV among YMSM¹² and the fact that individual behavior does not appear to explain these disparities^{16,17,19}, it is important to examine the extent to which syndemics are associated with HIV risk among Black MSM⁴² and if they can explain group disparities as well as individual risk.

While prior studies have played an invaluable role in understanding the role of syndemics in HIV among MSM, these existing studies have had several limitations. First, with two exceptions the majority of syndemic research to date has utilized cross-sectional, rather than longitudinal designs. One study by Mimiaga and colleagues that found a significant association between syndemics and 4 year HIV incidence in a sample of sexually active U.S. MSM from the EXPLORE study⁴³. A second longitudinal study in a cohort of Thai MSM also found an association with HIV incidence⁴⁴. Second, most analyses tend to use an additive model to create a syndemic component; in this approach the contributions of the individual psychosocial health issues to the syndemic construct are considered to be equal, which greatly simplifies the potentially complex association. Some researchers have begun to implement more sophisticated modeling techniques, such as latent variable structural equation modeling (SEM) of the syndemic construct^{21,31,45}, but these modeling approaches are rare. Another limitation in the existing literature is measurement, with most studies relying on self-reported HIV status or sexual risk behaviors rather than biomedical outcomes (several notable exceptions have tested for HIV^{21,43,44}). Similarly, most studies have relied on brief questionnaires or single items to measures syndemic components, which increases measurement error and reduces the ability to examine syndemic problems from a perspective of clinical meaningfulness.

The current study sought to expand upon prior research by using strong measurement of syndemic components, an SEM measurement modeling framework to estimate the syndemic, and a longitudinal study design to test the predictive syndemic relationship to HIV risk behavior. Rather than use an additive model, a higher-order factor analysis was performed using SEM to describe the syndemic component of interest. In this method, a hierarchical measurement model was constructed in which the three syndemic components of interest—substance use, violence, and internalizing mental health—were latent factors created from relevant observed variables. In turn, the primary syndemic component was constructed as a higher order factor indicated by the three lower order factors.

In addition to the primary aims of the study described above, an exploratory aim was developed to test whether or not the association between syndemic factors and HIV risk behavior was driven by an underlying personality disposition towards engaging in multiple health risk behaviors rather than a causal effect of syndemic conditions. This question is driven by decades of research showing that particular dimensions of personality (i.e., impulsivity) are associated with multiple psychosocial health outcomes that have been characterized as syndemic components (e.g., substance abuse⁴⁶) as well as with sexual risk taking behaviors among MSM^{47–49} and adolescents^{50–52}. As such, one hypothesis is that that the co-occurrence of syndemic factors among YMSM is a manifestation of an impulsive, risk-taking personality type. If this hypothesis were true, impulsivity should have a significant association with the syndemic indicators and HIV risk behavior, and if so then adding impulsivity in the same model as the syndemic factor should reduce or eliminate the effect of the syndemic factor on HIV risk behaviors.

We also examined the differential effect of the syndemic model across racial/ethnic groups. Most syndemic research with MSM has not represented racially/ethnically diverse populations—the Urban Men’s Health Study consisted of 79% White MSM⁵³ while other studies have looked exclusively at Black MSM^{42,54} or had few Black participants. While some prior studies have shown syndemic factors to be predictive of HIV risk among Black adult MSM^{43,55}, there are reasons to believe that syndemic theory may be less relevant to understanding HIV risk among Black YMSM. Chief among these reasons is the fact that Black YMSM have a much higher HIV prevalence than White YMSM^{2,55,56}, yet studies have found them to have lower or similar levels of some of the syndemic components^{12,16}. This pattern is consistent for substance use^{16,32,57,58} and internalizing mental health problems^{37,57} across studies using a variety of sampling and assessment methodologies. For example, an analysis of a school-based probability sample of adolescents found no significant Black-White differences among sexual minority boys (i.e., boys with same-sex attractions, gay/bisexual identities, same-sex behavior) in feelings of depression or aspects of suicidality³⁷. However, experiences of violence and victimization may show a different pattern, with some studies showing Black YMSM to have higher rates than White YMSM^{59,60}. Since the current study consisted of a diverse sample of YMSM, the syndemic and outcome differences between Black, White, and Latino YMSM were investigated. This allowed us to explore the extent to which a syndemic perspective could help understand racial disparities in HIV among YMSM.

Finally, our study explores the prospective relationship between syndemics and incident HIV and STIs measured after one year of longitudinal follow-up. Because very large samples are required to have sufficient power to detect significant effects on HIV/STI incidence outcomes, we consider these analyses to be exploratory.

METHODS

Survey Participants

Data were collected as part of a longitudinal study of YMSM conducted in Chicago and its vicinity between December 2009 and January 2015. An individual was eligible for participation if they were between the ages of 16 and 20 years, assigned a male sex at birth,

spoke English, reported a sexual encounter with a male or identified as gay/bisexual, and were available for two years of follow-up. Participants were recruited through a modified form of respondent-driven sampling (RDS)⁶¹ that allowed for a greater number of seeds than standard RDS^{62–64}.

Analyses used data from baseline and the first two follow-up visits (T2 and T3), which occurred approximately 6 months and 12 months after the baseline survey. Follow-up retention was high, with 85.8% and 80.7% of participants completing the assessment at T2 and T3, respectively. To reduce participant fatigue given the number of measures collected at baseline, this initial data collection point was split into two sessions completed within the same week. Self-report measures were collected using a computer-assisted self-interview (CASI) and participants were compensated \$70 for their time at baseline and \$45 at follow-up visits. All procedures were approved by the Institutional Review Boards (IRBs) of participating institutions.

Measures

Demographics—Demographic characteristics such as age, race/ethnicity, and sexual identity were assessed at baseline.

Sexual risk behavior—The HIV-Risk Assessment for Sexual Partnerships (H-RASP) is a computerized self-administered interview designed to assess sexual behavior and associated situational and contextual variables in the past six months⁶⁵. The sexual risk behavior outcome variable used in subsequent analyses was number of male condomless anal sex partners at T2.

Substance use—Alcohol use disorders were assessed using the Computerized Diagnostic Interview Schedule (C DIS-IV) for Diagnostic and Statistical Manual of Mental Disorders, 4th Edition (DSM-IV) and dichotomized based on whether respondents were classified with an alcohol abuse or dependence disorder in the past year⁶⁶. The C DIS-IV is a structured interview designed to identify the presence of DSM-IV psychiatric disorders. Details on the interview have previously been published⁵⁷. Binge drinking was assessed through the question “During the past 6 months, how often did you have 5 or more drinks containing alcohol within a two-hour period?” and dichotomized based on whether they reported at least one episode of binge drinking. In addition, participants were asked if they had used any of a list of drugs in the prior six months: marijuana, cocaine, heroin, methamphetamines, psychedelics, ecstasy, ketamine, GHB (gamma-Hydroxybutyric acid), inhalants, and poppers. Polydrug use was characterized as use of two or more of these drugs in the past 6 months.

Violence—Sexual orientation-based victimization in the prior six months was assessed through a set of 24 questions adapted from previously used measures of experienced stigma^{67,68}. A subset of four items most directly related to experiencing physical victimization (“How often have you been pushed around or beaten up because of the way you behaved?”, “How often have you been pushed around or beaten up because of your sexual orientation?”, “How often were you in a physical fight on school property because of

your sexual orientation?”, and “How often did someone threaten or injure you with a weapon on school property because of your sexual orientation?”) were used to construct a dichotomous indicator based on endorsement of any item. Also, participants were requested to provide information about their three most recent sexual partners in the prior six months. For each partner, they were asked a series of questions to assess IPV. A participant was classified as having experienced IPV if they answered in the affirmative to the question “Has [partner] ever hit, slapped, punched, or hurt you?” or “Did [partner] ever force you to have sex when you didn’t want to? (‘Force’ includes physical and non-physical pressure, such as pushing you, arguing with you or threatening you in order to have sex)” for at least one partner.

The early sexual experiences measure was administered to assess unwanted childhood sexual experiences before the age of thirteen⁶⁹. A binary variable representing unwanted childhood sexual experiences was computed if respondents indicated that any of the following events occurred when they did not want them to: “another person showed his or her sex organs to you,” “you showed your sex organs to another person at his or her request,” “someone touched or fondled your sexual organs,” “you touched or fondled another person’s sex organs at his or her request,” “another person had sexual intercourse with you,” “another person performed oral sex on you,” “you performed oral sex on another person,” “someone told you to engage in sexual activity so that he or she could watch,” “you engaged in anal sex with another person,” or other unwanted sexual experiences.

Mental health—Major depressive disorder in the past year was assessed using the depression module of the C DIS-IV⁶⁶. Also, suicide contemplation was defined by a participant answering in the affirmative to the question “During the past 6 months, did you ever seriously consider attempting suicide?” The Adult Self-Report (ASR), for participants aged 18 and older, and the Youth Self-Report (YSR), for participants younger than 18, from the Achenbach System of Empirically Based Assessment (ASEBA) were administered and t-scores were calculated for the internalizing anxious/depressed scale. T-scores less than 65 are considered within a normal range, values between 65 and 69 are considered borderline clinical, and scores above 69 are considered clinical. Both clinical and borderline clinical scores were combined to create a dichotomous variable.

HIV and STI testing—At the one-year follow-up (T3), participants were asked to complete HIV and urine-based STI testing. HIV incidence was determined through OraQuick/OrasureTM oral fluid test or through documentation of an antiretroviral therapy (ART) prescription or medical records. Nucleic acid amplification testing was conducted on urine specimens to test for the presence of *Neisseria gonorrhea* (GC) and *Chlamydia trachomatis* (CT). STI prevalence for the purpose of these analyses is defined by the presence of either GC or CT.

Impulsivity—Participants were administered a revised version of the UPPS Impulsive Behavior scale (UPPS-P) which is a set of 59 questions used to assess impulsivity^{70,71}. This revised version added an additional subscale – positive urgency ($\alpha = 0.92$) – to the original four that were created to measure different aspects of impulsivity– negative urgency ($\alpha = 0.84$), lack of premeditation ($\alpha = 0.84$), lack of perseverance ($\alpha = 0.79$), and sensation

seeking ($\alpha = 0.82$). All five subscales were included in the assessment of impulsivity within this sample.

Statistical Analyses

First, descriptive statistics and correlations were calculated to determine the occurrence and association of each first-order factor indicator. Then, confirmatory factor analysis (CFA) was conducted in order to examine model fit of the hypothesized factors: substance use, violence, and internalizing mental health. Mean and variance adjusted weighted least square estimation (WLSMV) was used since all nine factor indicators were categorical. Comparison among models with a single factor, three factors, a second-order with unequal loadings, and a second-order with loadings constrained to be equal was performed using the following indices: root mean square error of approximation (RMSEA), Comparative Fit Index (CFI), and weighted root mean square residual (WRMR)⁷². Although a recent article on syndemic modeling using latent factor analysis found that constraining factor loadings to be equal resulted in poorer model fit than allowing loadings to be unequal, the investigators recommended testing the assumption of loading equality, given the potential for variability across samples⁴⁵. In essence, testing the effect of setting factor loadings equal across syndemic components asks if a simple summing of syndemic components provides the best fit to the data, or do some components contribute more or less to the underlying syndemic construct? Therefore, we tested the effects of setting the second-order factor loadings equal to test the hypothesis that all three syndemic component indicators are equivalent.

After constructing a latent factor representing the syndemic construct, negative binomial regression using maximum likelihood estimation with robust standard errors (MLR) was performed to test for an association between this predictor and the number of male condomless anal sex partners at T2. In addition, logistic regression using WLSMV estimation was conducted to determine if the syndemic construct was associated with HIV incidence and STI prevalence at T3. Correlations were computed to assess the relationship between each syndemic component and impulsivity.

Multi-group analysis to compare Black YMSM to White and Latino YMSM based on syndemic components and number of male condomless sex partners at T2 could not be performed in Mplus due to the large number of parameters per observed data preventing model convergence. Therefore, for this exploratory analysis, factor scores from Mplus were exported and final racial/ethnic comparisons were conducted in SAS using the Kruskal-Wallis χ^2 test for syndemic component differences, and Spearman's rho to test for differences in association between the primary syndemic component and number of male condomless sex partners at T2 by race/ethnicity.

SAS v9.4 (Cary, NC) was used for computing descriptive statistics as well as assessing exploratory aims related to impulsivity and racial/ethnic differences. Mplus version 7.31 (Muthén and Muthén, Los Angeles, CA) was used for the remainder of the statistical analyses.

RESULTS

This sample of 450 YMSM was ethnically/racially diverse – more than one-half identified as Black (53.3%), 20.0% identified as Latino, 18.0% identified as White, and the remaining 8.7% were Asian, American Indian/Alaska Native, or another race/ethnicity. Mean age at baseline was 18.9 years ($SD = 1.3$), and three-quarters of participants identified as either “only gay” or “mostly gay” (50.2% and 22.9%, respectively), with 21.3% identifying as bisexual.

Syndemic Components

Table 1 provides the prevalence of syndemic components and their indicators by race/ethnicity. In terms of substance use, 7.4% of participants met the DSM-IV criteria for alcohol abuse or dependence disorder in the past year and 11.8% reported polydrug use in the past 6 months. Nearly all participants had experienced at least one form of sexual orientation-based victimization in the past 6 months (98.9%), with approximately one-quarter reporting instances of physical victimization (22.1%). Eight percent of YMSM seriously considered committing suicide at some point in the past 6 months. About one-fifth (17.8%) met the DSM-IV criteria for a major depressive episode in the prior year, and a similar proportion had symptomatology indicating either clinical or borderline clinical internalizing scale scores on the ASR/YSR (19.3%). The correlation between each of these observed variables and number of condomless anal sex partners is presented in Table 2. The indicators of the syndemic components generally showed significant, although relatively small, correlations. Additionally, the correlations with number of condomless anal sex partners were small.

Syndemic Model

To determine the most appropriate latent modeling approach, four CFA models with varying factor structures were examined with results presented in Table 3. Based on model fit statistics and theoretical considerations from prior literature, a second-order factor model with unequal factor loadings was selected as the most appropriate latent modeling approach ($CFI = 0.93$; $RMSEA = 0.03$; $WRMR = 0.85$). These results show that a second-order factor model with unequal factor loadings fit significantly better than the same model with equal factor loadings ($\chi^2(2) = 12.89$; $p < 0.01$), as determined by the Satorra-Bentler scaled χ^2 difference test^{73,74}. Each of the nine observed indicator variables and three first-order factors were significant ($p < 0.05$) contributors to their respective factors (Table 4).

Next, the number of male condomless anal sex partners was regressed on the second-order latent factor, hereafter referred to as the primary syndemic component. The primary syndemic component at baseline was found to be a risk factor for engaging in unprotected anal sex at T2 (Incident Rate Ratio [IRR] = 2.43; 95% confidence interval [CI]: 2.03, 2.92) while controlling for age and race/ethnicity. The path diagram for this analysis including standardized regression coefficients are presented in Figure 1.

Exploratory Aims

Biomedical Outcomes—Of the 337 participants who tested negative for HIV at baseline and completed the 12 month follow-up, 5.6% (n=19) were found to be positive at T3. Of these 19 incident cases, 14 (73.7%) occurred among Black participants. STI prevalence was 7.4% (n=26) at T3. After controlling for age and race/ethnicity (Black versus non-Black), no significant association was found between the primary syndemic component and HIV incidence (IRR = 0.81; 95% CI: 0.56, 1.16) or STI prevalence (IRR = 0.75; 95% CI: 0.56, 1.01).

Racial/Ethnic Differences—Black, White, and Latino MSM differed on a number of factors comprising the primary syndemic component (Table 1). White MSM were found to be more likely to report binge drinking than Latino MSM (odds ratio [OR] = 1.93; 95% CI: 1.02, 3.65). Compared to Black MSM, White MSM and Latino MSM were significantly more likely to report binge drinking (OR = 3.85; 95% CI: 2.23, 6.66 and OR = 2.00; 95% CI: 1.22, 3.26, respectively), alcohol use disorder (OR = 3.24; 95% CI: 1.30, 8.10 and OR = 2.88; 95% CI: 1.15, 7.16, respectively), polydrug use (OR = 4.92; 95% CI: 2.38, 10.17 and OR = 2.53; 95% CI: 1.15, 5.56, respectively), and having a depressive episode in the past year (OR = 1.92; 95% CI: 1.02, 3.62 and OR = 2.15; 95% CI: 1.18, 3.92, respectively). Conversely, White MSM were less likely to have experienced physical victimization (OR = 0.23; 95% CI: 0.09, 0.55) and unwanted childhood sexual experience (OR = 0.47; 95% CI: 0.28, 0.80) compared to Black MSM.

White and Latino MSM also reported a significantly larger number of male condomless anal sex partners than Black MSM (Kruskal-Wallis $\chi^2 = 14.66$; $p < 0.001$; data not shown). Based on this evidence, differences in syndemic factors among Black MSM, White MSM, and Latino MSM were tested. Generally consistent with differences in the observed variables, White MSM and Latino MSM both had significantly higher factor scores for the substance use component (Kruskal-Wallis $\chi^2 = 27.71$; $p < 0.0001$) compared to Black MSM. In addition, White MSM had significantly higher factor scores for the internalizing mental health component (Kruskal-Wallis $\chi^2 = 13.32$; $p < 0.01$) compared to Black MSM, but no significant racial/ethnic differences were found for the violence component (Kruskal-Wallis $\chi^2 = 1.28$; $p = 0.53$). Regarding the primary syndemic component, White MSM and Latino MSM also had significantly higher factor scores than Black MSM (Kruskal-Wallis $\chi^2 = 21.57$; $p < 0.0001$). When examining the association between the primary syndemic component and number of male condomless anal sex partners there was a significant positive association for White MSM (Spearman's $\rho = 0.27$; $p = 0.03$), but the associations for Latino or Black MSM were smaller and only statistical trends (Spearman's $\rho = 0.21$; $p = 0.06$ and Spearman's $\rho = 0.14$; $p = 0.05$, respectively).

Impulsivity

Several subscales of impulsivity were associated with syndemic components. Sensation seeking, negative urgency, and positive urgency were positively correlated with all syndemic components (Table 5). Lack of perseverance and lack of premeditation was positively correlated with the internalizing mental health, substance use and the primary syndemic components, but not with the violence component. Additionally, none of the impulsivity

subscales were associated with number of male condomless anal sex partners at T2. As such, the hypothesis that impulsivity may explain the association between syndemic factors and HIV risk behaviors was refuted, and no further multivariate models were tested.

DISCUSSION

Using SEM to perform higher-order factor analysis to identify a syndemic construct is an innovative way to investigate the joint influences of substance use, violence, and internalizing mental health on HIV risk behaviors such as condomless anal sex. Within this study, we found that all three syndemic factors, comprised of multiple indicators, contributed significantly to the primary syndemic component in the measurement model, with substance use providing slightly more information than the other two factors. However, in the full SEM analysis predicting HIV risk behavior, the violence component was no longer a significant indicator of the syndemic. These results call into question the assumption of unidimensionality and equal component contribution in the additive model frequently employed in syndemics research. Thus, while there is evidence of predictive utility of the additive approach, it may underestimate the effects of individual components on outcomes of interest. This potential issue, coupled with concerns that the additive model does not truly test the “interactive” or “synergistic” epidemics implied in the syndemics literature^{75,76}, suggests the need for further study of quantitative approaches that can better test the postulates of a syndemic perspective.

Similar to prior research^{20,24,28,42,54}, we found that the primary syndemic component was a significant predictor of HIV risk behavior within this sample of YMSM, although the effect size was small. Our study extends the prior literature by demonstrating this association prospectively in a longitudinal cohort study of diverse YMSM. We also explored the prospective association with incident HIV and STIs across one year, and these associations were not significant; in fact, the point estimates were in the opposite direction of a hypothesized syndemic effect. Prior studies have found a prospective association among MSM, including in the 4,295 MSM followed for 4 years in the EXPLORE study (72.5% White, 6.5% Black)⁴³ and the 1,292 Thai MSM followed for 3–5 years⁴⁴. Our lack of significant effects may be due to low power in our sample of 450 participants, but the direction of effects implies that perhaps these syndemic factors are less related to HIV incidence in our sample. Future research, in larger samples, is needed to verify the predictive power of the syndemic component for condomless anal sex on acquisition of HIV or other biomedical endpoints like STIs among YMSM of color who are at the greatest risk for HIV in the US.

Within this study, in sub-group analyses, the predictive value of the syndemic components differed by race/ethnicity. Consistent with previous studies, Black YMSM had lower levels of the risk factors comprising the syndemic component (polydrug use, binge drinking, etc.) than their White and Latino counterparts^{12,13}. Black YMSM also reported significantly fewer condomless anal sex partners. Furthermore, when estimating the predictive effect of syndemics separately by race/ethnicity, White YMSM were the only group to show a significant relationship. Taken together, these findings suggest that these individual-level syndemic factors (as defined in this study) are unlikely to explain racial disparities in HIV

among YMSM and suggest they may play less of a role in explaining individual risk among YMSM of color. A preponderance of literature has shown that we cannot generalize White MSM- or overall MSM-findings to Black MSM when attempting to gain a better understanding of the HIV epidemic among that population^{10,13,77}. Future syndemic research should include sensitivity analyses to identify and replicate these findings. Given evidence to support syndemic theory among adult Black MSM^{42,54}, this finding requires additional exploration and analysis, particularly over time in longitudinal studies. Further research is also needed to determine if other conditions and/or behaviors may comprise syndemic factors specific to Black YMSM. As mentioned, some studies employing a syndemic perspective have included additional syndemic indicators beyond those included in the current study (e.g., sexual compulsivity²⁶), and as of yet there is no clear consensus in the literature of what psychosocial health issues comprise the syndemic among MSM or Black YMSM in particular. There is also the possibility that by focusing on the individual-level the syndemic perspective has limited utility for advancing our understanding of the disproportionate spread of HIV among Black YMSM. Since Black YMSM have the highest HIV incidence among all MSM, it is vital to develop models that help to explain the drivers of infection within this population. There is a growing body of evidence suggesting that individual-level characteristics may not explain disproportionate HIV incidence in Black YMSM; network-level and neighborhood-level factors show promise in increasing our understanding of the epidemic among this sub-population^{12,78–80}.

We found that all measures of impulsive behavior were correlated with at least two syndemic components. Although research into the role that an impulsive personality plays in engagement in risk behaviors among YMSM has been suggested²⁰, most studies have examined this association in older HIV-positive MSM^{47,48} and in general samples of adolescents^{81–84}. Therefore, this represents one of the first instances in which impulsivity has been linked to substance use, mental health disorders, and violence among YMSM. Despite these correlations, impulsivity was not associated with engagement in condomless anal sex among this sample of YMSM. Although this is counterintuitive, it corresponds with findings among HIV-positive MSM⁴⁸; Semple et al. found that impulsivity was only associated with unprotected sex after controlling for covariates such as age and education. Thus, our findings might be confounded by factors not included in the model and subsequent research is needed to further investigate what role, if any, impulsivity plays in sexual risk behaviors among YMSM. As they stand, the pattern of results does not suggest impulsivity underlies the syndemic-risky sex association.

This study has several limitations. While we used state-of-the-art measurement approaches (e.g., structured psychiatric interviews, CASI), all data were reliant on self-report, which could contribute to a variety of biases, including recall bias and social desirability bias. All questions were time-anchored to the last 6 months or last year in order to minimize recall bias. Additionally, interviews were conducted using CASI technology, which has been shown to reduce reporting biases including social desirability bias⁸⁵. HIV risk was assessed by the rate of condomless anal sex, and did not incorporate information on risk reduction strategies such as serosorting or biomedical prevention. PrEP was not FDA approved and the impact of treatment as prevention had not been demonstrated at the time these data were collected. This study recruited participants from one urban location; therefore, findings

might not be generalizable to rural YMSM or YMSM who live in other cities in the United States.

CONCLUSIONS

Syndemic theory continues to be used to explain the rapid spread of HIV throughout YMSM in the United States. We found evidence to support the predictive ability of syndemic factors on engagement in risk behaviors that could lead to HIV acquisition, but no association with HIV/STI incidence. An important caveat is that the syndemic perspective does not appear to be as applicable for Black YMSM; the prevalence of behaviors that comprise the syndemic, as well as of high-risk sexual behaviors was significantly lower among Black YMSM, potentially resulting in a lack of evidence for syndemic influences. Future research is needed to determine if syndemic theory, albeit with different component factors, can be used to explain the high rates of HIV acquisition among Black YMSM, or if this construct and possibly others that focus on individual-level behavior and characteristics, have less utility in advancing our understanding of the epidemic among this important risk population.

Acknowledgments

Funding: Data collection for this study was funded by the National Institute on Drug Abuse (R01DA025548). Analyses and manuscript preparation were supported by a grant from the National Institute on Drug Abuse (U01DA036939). We acknowledge the support of the Third Coast Center for AIDS Research (CFAR), an NIH funded center (P30AI117943). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institute of Drug Abuse or the National Institutes of Health.

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Figure 1.
 Syndemic model predicting number of condomless anal sex acts at T2.
 Note: All values presented are standardized β .
 * $p < 0.05$; ** $p < 0.01$

Table 1

Prevalence of syndemic components stratified by race/ethnicity.

	White (n=81) n (%)	Black (n=240) n (%)	Latino (n=90) n (%)	Other (n=39) n (%)	Total (n=450) n (%)
Substance Use					
Binge drinking ^{a, b, c}	58 (71.6)	95 (39.6)	51 (56.7)	21 (53.9)	225 (50.0)
Alcohol use disorder (DSM-IV) ^{a, b}	10 (12.4)	10 (4.2)	10 (11.1)	3 (8.1)	33 (7.4)
Polydrug use ^{a, b}	20 (24.7)	15 (6.3)	13 (14.4)	5 (12.8)	53 (11.8)
Violence					
Sexual orientation-based physical victimization ^{a, d, e}	6 (7.5)	61 (26.4)	15 (16.7)	15 (38.5)	97 (22.1)
Victim of IPV	9 (11.1)	35 (14.8)	15 (16.7)	8 (21.6)	67 (15.1)
Unwanted childhood sexual experience ^a	28 (34.6)	126 (52.7)	37 (41.1)	14 (35.9)	205 (45.7)
Internalizing Mental Health					
Serious suicidal contemplation ^f	9 (11.1)	15 (6.3)	7 (7.8)	6 (15.4)	37 (8.2)
Major depressive episode (DSM-IV) ^{a, b}	19 (23.5)	33 (13.8)	23 (25.6)	5 (13.2)	80 (17.8)
Internalizing anxious/depressed (ASR/YSR)	19 (23.5)	38 (15.8)	19 (21.1)	11 (28.2)	87 (19.3)

^a significant difference between Black and White participants ($p < .05$).^b significant difference between Black and Latino participants ($p < .05$).^c significant difference between White and Latino participants ($p < .05$).^d significant difference between White and Other participants ($p < .05$).^e significant difference between Latino and Other participants ($p < .05$).^f significant difference between Black and Other participants ($p < .05$).

Note: Missing data has been excluded from the denominator when calculating the percentage.

Table II

Correlation matrix of syndemic indicators and distal outcomes

	1	2	3	4	5	6	7	8	9
1. Binge Drinking									
2. Alcohol Use Disorder (DSM-IV)	.26**								
3. Polydrug Use	.21**	.16**							
4. Sexual Orientation-Based Physical Victimization	.04	.00	-.06						
5. Victim of IPV	.11*	.10*	.06	.09					
6. Unwanted Childhood Sexual Experience	.07	.03	-.00	.13**	.17**				
7. Serious Suicidal Contemplation	.09	-.05	.22**	.00	-.01	.02			
8. Major Depressive Episode (DSM-IV)	.16**	.05	.14**	-.05	.03	.11*	.16**		
9. Internalizing Anxious/Depressed (ASR/YSR)	.10*	.06	.10*	.07	.01	.07	.20**	.17**	
10. Number of Condomless Anal Sex Partners at T2	.16**	.10	.17**	-.14*	-.01	-.01	.01	.17**	.08

p<.01;

*

p<.05

Table III

Model fit statistics for confirmatory factor analysis

	χ^2	df	p-value	CFI	RMSEA	WRMR
One-factor model	73.19	27	0.000	0.76	0.06	1.23
Unrestricted three factor model	36.61	24	0.048	0.93	0.03	0.85
Second-order factor model with unequal loadings	36.61	24	0.048	0.93	0.03	0.85
Second-order factor model with equal loadings	51.65	26	0.002	0.87	0.05	1.04

Note: The second-order factor model with unequal factor loadings fit significantly better than the same model with equal factor loadings ($\chi^2(2) = 12.89$; $p < .01$), as determined by the Satorra-Bentler scaled χ^2 difference test. CFI = Comparative Fit Index; RMSEA = Root Mean Square Error of Approximation; WRMR = Weighted Root Mean Square Residual

Table IV

Standardized coefficients for second-order factor model with unequal loadings

	β	SE	p-value
First-Order Factors			
Factor 1: Substance Use			
Binge drinking	0.89	0.12	<.001
Alcohol use disorder (DSM-IV)	0.73	0.11	<.001
Polydrug use	0.57	0.09	<.001
Factor 2: Violence			
Sexual orientation-based physical victimization	0.30	0.12	0.011
Victim of IPV	0.60	0.17	<.001
Unwanted childhood sexual experience	0.58	0.15	<.001
Factor 3: Internalizing Mental Health			
Major depressive episode (DSM-IV)	0.62	0.12	<.001
Serious suicidal contemplation	0.62	0.13	<.001
Internalizing anxious/depressed (ASR/YSR)	0.56	0.10	<.001
Second-Order Factor			
Primary Syndemic Component			
Factor 1: Substance Use	0.72	0.23	0.002
Factor 2: Violence	0.36	0.13	0.007
Factor 3: Internalizing Mental Health	0.67	0.22	0.003

Note: Model fit statistics: CFI = .934; RMSEA = .034; WRMR = .851.

Table V

Correlations between UPPS measures of impulsivity and syndemic components.

	Substance Use Factor	Violence Factor	Internalizing Mental Health Factor	Primary Syndemic Component	Number of Condomless Anal Sex Partners
	Spearman ρ	Spearman ρ	Spearman ρ	Spearman ρ	Spearman ρ
Lack of Perseverance Subscale	0.11 *	0.05	0.17 **	0.13 **	-0.01
Lack of Premeditation Subscale	0.18 **	0.01	0.16 **	0.16 **	0.03
Sensation Seeking Subscale	0.25 **	0.15 **	0.19 **	0.24 **	0.04
Negative Urgency Subscale	0.21 **	0.20 **	0.27 **	0.24 **	0.03
Positive Urgency Subscale	0.12 *	0.13 **	0.15 **	0.13 **	-0.07

*
p<0.05;**
p<0.01