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Longitudinal effects of syndemics on HIV-positive sexual minority men's sexual health behaviors

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Abstract

Objective—This study examined the longitudinal effects of co-occurring psychosocial concerns, or syndemics, on HIV-positive sexual minority men's likelihood of engaging in serodiscordant condomless anal sex (CAS), a health behavior with implications for personal and public health.

Methods—Participants included 390 HIV-positive sexual minority men from two prior secondary prevention trials. Over the course of the one-year data collection period (up to 5 observations per participant), participants completed self-report measures of CAS, as well as six syndemic factors: post-traumatic stress disorder, childhood sexual abuse, depression, anxiety, alcohol abuse, and poly sub stance/stimulant use. We employed multilevel modeling to examine the longitudinal additive effect of syndemics on serodiscordant CAS (binary) over the one-year period.

Results—The number of syndemic conditions was a significant predictor of CAS, with each additional syndemic associated with 1.41 greater odds of CAS ($p = 0.0004$; 95% CI [1.16, 1.70]). Both the between- ($p = 0.0121$, 95% CI [1.07, 1.69]) and within-person ($p = 0.01$, 95% CI [1.11, 2.10]) effects of syndemics were significant predictors, showing that an increase in the number of syndemic conditions across person and time both increased odds of CAS.

Conclusions—Interventions addressing HIV-positive sexual minority men's sexual health behaviors should address the potential impact of co-occurring psychosocial concerns that affect

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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.

Informed Consent: Informed consent was obtained for all participants included in the study.

these behaviors. This will benefit this population's personal sexual health and reduce transmission of HIV and STIs among sexual minority men.

Keywords

HIV/AIDS; men who have sex with men/MSM; syndemic; sexual behavior; secondary HIV prevention

HIV disproportionately affects sexual minority men (men who identify as gay, bisexual, or another non-heterosexual identity) and other men who have sex with men (MSM) in the United States in terms of both incidence and prevalence. The most recent figures show that at year end of 2015, 59.5% people in the United States living with HIV were MSM and in 2016, 70% of newly diagnosed HIV cases in the United States were MSM (CDC, 2017). Additionally, rates of mental health and associated psychosocial problems among people living with HIV in the U.S. are disproportionately high (Bing et al., 2001; Brandt et al., 2017; Hartzler et al., 2017; O'Cleirigh, Magidson, Skeer, Mayer, & Safren, 2015).

Sexual minority men, regardless of HIV status, experience elevated rates of various mental health problems, including depression, anxiety, psychological distress, self-harm behavior, and alcohol and substance use, as compared to their heterosexual counterparts (Cochran, Greer, & Mays, 2003; King et al., 2008), which is likely due to sexual minority stress (Meyer, 2003). Some of these problems have been shown to be associated with each other and with adverse health behaviors and outcomes (Hirshfield, Remien, Humberstone, Walavalkar, & Chiasson, 2004; Mimiaga et al., 2009; O'Cleirigh et al., 2015; Reisner, Mimiaga, Safren, & Mayer, 2009; Stall et al., 2003; Williams et al., 2015; Wim, Christiana, & Marie, 2014).

A syndemic occurs when a constellation of psychosocial concerns co-occurs in a population and synergistically affects the odds of different health outcomes and health behaviors within that population (Singer & Clair, 2003; Singer et al., 2006). Syndemics theory states that when multiple conditions occur simultaneously, they can worsen the burden of disease on a population and amplify the negative consequences of the individual conditions through their interaction, ultimately heightening health disparities across social groups.

The frequency of syndemics among sexual minority men and their association to HIV acquisition risk behavior has drawn significant research attention. The majority of existing studies are cross-sectional and include samples of primarily HIV-negative individuals or MSM regardless of HIV status (Dyer et al., 2012; Ferlatte, Hottes, Trussler, & Marchand, 2014; Herrick et al., 2013; Mimiaga, Biello, et al., 2015; Mustanski, Garofalo, Herrick, & Donenberg, 2007; Parsons, Grov, & Golub, 2012; Parsons et al., 2017; Stall et al., 2003; Storholm, Satre, Kapadia, & Halkitis, 2016; Tulloch et al., 2015). However, some of these studies had self-reported HIV-positive status as an outcome (Mimiaga, Biello, et al., 2015; Mustanski et al., 2007; Parsons et al., 2012; Stall et al., 2003). More recently, longitudinal studies have examined the association between syndemics and behaviors that could lead to HIV transmission among HIV-negative sexual minority men. Among Thai MSM, a greater quantity of syndemic conditions (forced sex, suicidality, club drug use, alcohol intoxication, selling sex) predicted greater odds of incident HIV infection (Guadamuz et al., 2014). This

was the first study to show longitudinal evidence of this syndemic effect. Another study found that the number of syndemic indicators (including depression, alcohol abuse, stimulant use, polysubstance use, and childhood sexual abuse) among MSM was additively associated with CAS and seroconversion over a four-year period (Mimiaga, O'Cleirigh, et al., 2015). Another longitudinal study of young MSM found that greater numbers of syndemics, including substance use, sexual orientation-based violence, and anxiety/depression, were associated with greater likelihood of CAS (Mustanski et al., 2017).

Fewer studies have examined syndemics in HIV-positive individuals. Three of these studies utilized medication adherence as outcomes (Blashill et al., 2015; Friedman et al., 2015; Harkness et al., 2018) and generally found that greater numbers of syndemics were associated with worse adherence. One study examined the association of syndemics and sexual behavior for adolescents living with HIV (not specifically MSM) and found that substance use, emotional distress, and lack of social support formed a syndemic predictive of condomless sex (van den Berg et al., 2017). However, no studies to the authors' knowledge have examined longitudinally the association between syndemics and behaviors that could lead to HIV transmission, such as serodiscordant CAS, among sexual minority men living with HIV. This is an important area of research due to the disproportionate burden of HIV among sexual minority men, the high levels of syndemics in this population, and the potential for different syndemics to moderate the effects of existing secondary prevention interventions (Safren, Blashill, & O'Cleirigh, 2011). In order to improve and tailor these interventions to improve effectiveness, it is important to better understand and document the relationship between psychosocial syndemics and sexual health behaviors among this population. Therefore, this study assessed the longitudinal additive effects of six syndemic psychosocial concerns on the likelihood of serodiscordant CAS within a group of sexual minority men living with HIV. This study hypothesized that overall, greater numbers of syndemic conditions would contribute to increased likelihood of serodiscordant CAS over time.

Method

Participants

Participants are from two prior secondary prevention trials for sexual minority men (Safren, O'Cleirigh, Skeer, Elsesser, & Mayer, 2013; N = 390; Safren, O'Cleirigh, et al., 2011). The two trials, Project *Enhance*, an RCT in which the intervention was delivered by medical social workers) and a peer-delivered version of the same intervention, sought to reduce serodiscordant CAS among HIV-positive sexual minority men. Data for these studies were collected from 2004 to 2008. For Project *Enhance*, baseline condomless sex was part of the eligibility criteria; in contrast, baseline condomless sex was not required for the *Peer* intervention. All participants completed a baseline visit, at which point they provided informed consent and completed behavioral and psychosocial assessments. Participants in the peer-delivered trial all received the intervention, whereas those in the Project *Enhance* trial were randomized to either receive treatment or the control condition (treatment as usual in primary care). Participants who received the intervention sessions (*Peer* and *Enhance treatment)* covered a variety of topics, such as having sex, using substances, managing

stress, exploring triggers for different sexual behaviors, understanding culture and identity, disclosing HIV status, and developing effective relationships (see Knauz et al., 2007 for a description of the interventions and their development). Following study completion, participants completed follow up visits every three months, up to one year, yielding five possible assessment points per participant. All sessions were completed at Fenway Community Health, an organization that provides services to HIV-positive and sexual and gender minority community members.

Measures

The same measures were administered in both of the studies from which the participant data was drawn.

Condomless Anal Sex (CAS)—Participants were asked how many times they had condomless anal sex with a negative or unknown status male partner in the past three months. Because responses to this question were highly zero inflated, we elected to treat this as a binary variable, such that participants were coded as either 0 (no CAS) or 1 (CAS) in the past three months.

Syndemics—Participants completed assessments of six possible co-occurring psychosocial syndemic concerns, including childhood sexual abuse (CSA), post-traumatic stress disorder (PTSD), anxiety disorders, depression, alcohol abuse, and polysubstance and/or stimulant use, which are described below. Syndemics scores reflect the total number of syndemic conditions for which participants met criteria at each time point. Because there were six syndemic conditions assessed, participants' syndemics scores ranged from 0 (no syndemic conditions) to 6 (all syndemic conditions). A prior study using the same syndemic conditions showed that, consistent with syndemics theory, these syndemic conditions were largely co-occurring (Harkness et al., 2018). Logistic regression analyses revealed significant associations ($p < 0.05$) between seven of the pairs of psychosocial concerns and four associations that trended in the expected direction ($p < 0.10$). For example, individuals with baseline anxiety had 10.5 (95% CI [5.28,20.88]) greater odds of also having baseline depression. Although co-occurring, they were not redundant (Kappa = 0.338). Some were both depressed and anxious, whereas others were depressed only or anxious only. Following syndemics theory, which holds that intertwined, co-occurring psychosocial concerns would have a worse effect on other health outcomes (e.g. HIV-related health behaviors), we retained all six syndemic conditions in our syndemics variable.

CSA: CSA was assessed using the Juvenile Victimization Questionnaire (Finkelhor, Hamby, Ormrod, & Turner, 2005) at baseline only, as it is a past event that occurred in childhood. Participants who reported having a sexual experience with (1) someone at least five years older, before the age of 13 and/or (2) someone at least ten years older between age 13 and 16 years met criteria for CSA.

PTSD: PTSD was assessed using the SPAN (assesses startle, physiological arousal, anger, and numbness; Meltzer-Brody, Churchill, & Davidson, 1999). The SPAN scoring guidelines determined whether they met criteria for PTSD.

Anxiety disorders: Participants were assessed for social anxiety disorder, panic disorder, and generalized anxiety disorder. The Mini Social Phobia Inventory assessed for social anxiety disorder (Connor, Kobak, Churchill, Katzelnick, & Davidson, 2001) at baseline. The Patient Health Questionnaire (PHQ) assessed for panic disorder and other anxiety disorder (comparable to generalized anxiety disorder; Spitzer, Kroenke, & Williams, 1999) at all time points. Standard scoring procedures and score cutoffs determined whether participants met criteria for social anxiety disorder, panic disorder, and/or generalized anxiety disorder. If they met criteria for any of these three, they met criteria for the composite anxiety disorder variable.

Depression: Participants completed the PHQ (Spitzer et al., 1999), and the standard scoring procedures and score cutoff determined if they met criteria for depression.

Alcohol abuse: Participants reported binge drinking (five or more alcoholic drinks in a day) frequency in the past three months. Those who reported a frequency of one episode or more of binge drinking per week met criteria for alcohol abuse.

Polysubstance and/or stimulant use: Participants reported past three-month sniffing, snorting, smoking, or swallowing substances and/or past 30 day injecting substances. Substances assessed included: (1) marijuana, (2) crack, (3) cocaine, (4) heroin, (5) methamphetamine or amphetamine, (6) ketamine, (7) opiates such as Vicodin, OxyContin, Dilaudid, Percocet, or Darvocet, (8) tranquilizers or barbiturates (e.g. Valium, Xanax, GHB), (9) hallucinogens (e.g. LSD, ecstasy), (10) inhalants (e.g. glue, poppers, nitrous oxide), (11) steroids, or (12) other drugs not listed. The questionnaire did not specifically probe for opiate use as prescribed for pain compared to recreational use, as this study took place prior to the increased national conversation regarding the opioid crisis. Additionally, participants reported past three month crystal methamphetamine use in another questionnaire which we merged into the prior substance use questions. Participants who met criteria for polysubstance use (reported using three or more substances in the past three months) or stimulant use (reported crack, cocaine, and/or methamphetamine/amphetamine use in the past three months) met criteria for this composite variable.

Analytic Plan

Multilevel modeling of the longitudinal effect of syndemics on CAS—Multilevel modeling (MLM) was employed using SAS 9.4 (PROC GLIMMIX) to evaluate the longitudinal effects of syndemics on CAS. Repeated measures were taken every three months over the course of one year, which yielded a dataset of up to five evenly spaced observations nested within each participant. MLM was used because it accounts for repeated measures within individuals and affords the flexibility to include participants with missing data at particular time points (Jackson, 2010).

Predictors of CAS included time (continuous, coded 0 to 4), condition (categorical: *Enhance* control = reference), a time by condition interaction, and number of syndemics (continuous, coded 0 to 6). Because this was a secondary analysis of participant data from two prior intervention studies, time, condition (which study they were in, and for *Enhance* whether it

was intervention or control group), and condition by time interactions were used as covariates. In each model, statistical significance was determined using a conventional $p < .05$.

The models were fitted to predict binary CAS in PROC GLIMMIX using Maximum Likelihood estimation (Gauss-Hermite Quardrature) and a logit link function. The unconditional model was first used to compute the ICC, or the variation in CAS, due to between versus within-person effects. Following this, a random effect of time and fixed effect of time, condition, a condition by time interaction term, and number of syndemics were added to the model. The predictor of interest was the number of syndemics, with the remaining variables included as covariates.

Additional variables were considered but not used based on preliminary testing. Although the study was conducted before the findings of "Undetectable = Untransmittable," and therefore participants in this study were not making sexual decisions using this information, we considered using viral load (binary, detectable vs. undetectable) as a moderator within our model. This, however, was not significant ($p = 0.44$) and therefore dropped from further analysis. Additionally, lagged effects of syndemics were considered, but ultimately excluded due to statistical issues with multicollinearity, such that the syndemics score and lagged syndemics scores were highly correlated ($r = 0.85$).

Our analyses evaluated the between-person effect compared to the within-person effect of syndemics on participants' odds of engaging in serodiscordant CAS. Between person effects were used to examine whether variation in serodiscordant CAS is longitudinally associated with participants' average syndemic level over time compared to other participants in the study. Within person effects test whether CAS is longitudinally associated with participants' changes in syndemic levels compared to their average syndemics level across the year-long observation period. To examine the within- and between-person effects of syndemics on serodiscordant CAS, we disaggregated syndemics scores into a person mean (the person's average level of syndemics over the year they were observed) and a deviation from the mean (how far their syndemics score at a given time point was from their overall average syndemics score). The final model included the disaggregated syndemics scores (person mean and deviation from the mean) replacing the overall syndemics score (Curran & Bauer, 2011). This allowed us to examine within- and between-person effects of syndemics on serodiscordant CAS.

Results

Demographics

Complete demographic information for this sample is reported elsewhere (Harkness et al., 2018). Participants ranged in age from 21 to 68 years old ($M = 41.95$, $SD = 8.2$). The majority of participants were white ($n = 299$, 76.7%), followed by Black/African American ($n = 41$, 10.5%), Hispanic/Latino ($n = 30$, 7.7%), or another race or ethnicity ($n = 20$, 5.2%). They were mostly not in a committed relationship ($n = 232$, 59.5%), whereas about a third were in committed relationships ($n = 150$, 38.5%). In terms of their HIV health at baseline,

about half had an undetectable viral load (n = 218, 55.9%) and their average CD4+T cell count was 536 (SD = 289).

Syndemic Conditions & CAS – Preliminary Analyses

All of the syndemic conditions occurred at relatively high frequencies. The most frequently observed syndemic conditions (30% or more of the sample at any time point) were CSA, PTSD, anxiety, and poly sub stance/stimulant use (see Appendix 1 in the online appendix for description of the frequencies of each syndemic condition over time).

Figure 1 shows that at all time points, the modal syndemics score was 1. About 20% of the sample reported 0 or 2 syndemic conditions at each time point. Approximately 5-15% of the sample reported 3 or 4 syndemic conditions at any time point. Syndemics scores of 5-6 were less common at all time points.

Across the five time points, the number of participants who reported serodiscordant CAS ranged from approximately 27% to approximately 43%. As shown in Figure 2, there was a time effect across the full sample for CAS, such that over time, the frequency of CAS decreased.

Longitudinal Effect of Syndemics on CAS

We tested a series of three models, which are summarized in Table 1. The first was the unconditional model, with no predictors entered. The second included all of the predictors and tested our main hypothesis. The third disaggregated syndemics into between- and within-person effects.

First, we examined the unconditional model in order to partition the observed variance in CAS into between- and within-person components and to compute the ICC. Because error is implied by the response distribution, rather than estimated in hierarchical generalized linear models, the ICC was computed by assuming a variance of 3.29 for the logistic distribution of the binary outcome variable, CAS (Goldstein, Browne, & Rasbash, 2002). With the observed between-person variance ($\boldsymbol{\tau}$ = 4.87) and the assumed within-person variance ($\boldsymbol{\sigma}$= 3.29), the ICC (0.59) showed that approximately 60% of the variability in CAS was between persons, and the remaining attributable to within-person differences.

In a second model, we tested the fixed and random effects for our full set of predictors. Regarding the control variables, the model showed that the fixed effect of time (γ = −0.56, SE = 0.13, t(343) = −4.25, p < 0.0001), intervention condition (F(2,806) = 35.22, p < 0.0001) and the time by intervention condition interaction (F(2,806) = 3.52, p = 0.03) were significant. As predicted via the primary study hypothesis, syndemics was a significant predictor of CAS over and above the control variables, such that for each additional syndemic condition, participants were 41% more likely to report CAS (OR = 1.41; 95% CI [1.16, 1.70]; p = 0.0004).

Finally, the third model disaggregated participants' syndemics scores at each time point into an overall person mean (their average syndemics score across the five time points; between-person effects) and the deviation from their mean at each time point (the difference between

their observed syndemics score and their average syndemics score; within-person effects). In this model, we replaced the syndemics score from model 2 with these disaggregated variables for syndemics. All other covariates remained the same. This model showed that both the within- and between-person effects of syndemics were significantly predictive of serodiscordant CAS. Accordingly, the between person effect of syndemics revealed that participants' average number of syndemics across the five time points was a significant predictor of CAS, $t(806) = 2.51$, $p = 0.0121$. A mean syndemics score increase of 1 was associated with 1.34 (95% CI [1.07, 1.69]) greater odds of CAS. The within person effect of syndemics over time, $t(806) = 2.58$, $p = 0.01$ revealed that a one unit increase in the syndemics score at a given time point (compared to their average score) was associated with 1.56 (95% CI [1.11, 2.10]) greater odds of CAS over time. In other words, participants' syndemics scores significantly predicted serodiscordant CAS (Model 2), and this effect was attributable to within person changes in syndemics scores *and* between person differences in average syndemics scores (Model 3). Figure 3 illustrates the odds ratios associated with a one unit increase in each of the three syndemics scores we evaluated through models 2 and 3.

Discussion

Our study shows that co-occurring syndemic conditions are associated with greater likelihood of engaging in serodiscordant CAS among sexual minority men living with HIV. The findings were significant when comparing participants to each other, as well as when looking at individuals: those with higher average syndemics levels were more likely to engage in serodiscordant CAS, and if a participant had more syndemics than their average at a particular visit, they were also more likely to engage in serodiscordant CAS. Together, the syndemic conditions observed in this study (childhood sexual abuse, PTSD, depression, anxiety, poly sub stance/stimulant use, and alcohol abuse) longitudinally predicted serodiscordant CAS. This study builds on prior findings that syndemics are associated longitudinally with another health behavior, ART adherence, among sexual minority men living with HIV (Friedman et al., 2015; Harkness et al., 2018) and cross-sectional research showing the relationship between syndemics and condomless sex among a general population of adolescents living with HIV (van den Berg et al., 2017). This is the first study to the authors' knowledge to show this longitudinal relationship between syndemics and serodiscordant CAS among HIV-positive sexual minority men.

In addition to our main finding, we found both a between- and within-person effect of syndemics on CAS. In our sample, participants' average syndemics level over the one-year period was associated with their odds of engaging in CAS. Additionally, the change in their syndemics level from one time point to the next was associated with CAS. Different factors could explain these unique relationships, which may be useful to explore in future research. For those who had a higher overall level of syndemics over time, it could be that managing chronic, high levels of stress due to multiple psychosocial problems over time requires substantial use of one's cognitive coping resources, leaving few resources to plan or engage in additional self-care behaviors when these coping resources are already depleted. For instance, chronic stress from these different psychosocial conditions over time could affect one's self-efficacy for asserting or negotiating condom use or for HIV status disclosure as

well as the perceived benefits of these behaviors (i.e. Klein, 2011). There may be unique mediators, such as distress intolerance or emotion dysregulation, for those who had a relative elevation in syndemics level from one time point to the next. Puckett et al. (2017) showed that negative urgency, or a pattern of acting impulsively in response to distress, moderates the link between internalized stigma and CAS in young MSM, suggesting the potential utility of distress tolerance training for individuals with higher levels of negative urgency. Related, Rendina et al. (2017) found that among HIV-positive sexual minority men, difficulties with emotion regulation mediated observed relationships between internalized stigma and serodiscordant CAS. Future studies might examine these and other potential mediators and moderators of the relationship between syndemics and sexual behavior in order to tailor individual interventions and develop structural interventions.

Additionally, this study of sexual minority men living with HIV showed high rates of syndemic psychosocial conditions. We compared the rates of syndemic conditions observed in this study to two prior samples of sexual minority men: a cross-sectional sample of mostly HIV-negative sexual minority men collected in New York City from 2003-4 (Parsons et al., 2012) and a longitudinal sample of HIV-negative MSM collected in multiple U.S. cities from 1999-2001 (Mimiaga, O'Cleirigh, et al., 2015). Participants in this study had similar rates of childhood sexual abuse (44.9%) to Mimiaga, O'Cleirigh et al. (2015; 37.5% - 41.6%) but lower than Parsons et al. (2012; 10.2%). This could be associated with differences in measurement. Sexual minority men in this sample had lower rates of depression (11.6% - 13.8%) compared to the prior studies which used the Center for Epidemiological Studies Depression Scale (Parsons et al. = 47.4%; Mimiaga et al. = 35.4% - 47.3%). Alcohol abuse was somewhat higher in this sample (13.7% - 20.3%) than Mimiaga et al. (4+ drinks daily or 6+ drinks on a typical drinking day; 4.9% - 10.5%). This sample also had higher polysubstance/stimulant use (22.0% - 37.7%) compared to the other studies (Parsons et al., polysubstance = 8.4%; Mimiaga et al., polysubstance = 5.9% - 13.7% and stimulant = 16.9% - 25.1%). Consistent with other studies, this group of participants was quite burdened with syndemic psychosocial concerns.

A limitation of this study and area for future research is the time at which the data was collected and accounting for viral load detectability when examining the relationship between syndemics and serodiscordant CAS. We chose to examine serodiscordant CAS as the outcome for this longitudinal model, using all of the HIV-positive sexual minority men in the sample because data was collected prior to the dissemination of the "Undetectable = Untransmittable" public health messaging (Cohen et al., 2011; Rodger et al., 2016). We were interested in examining the association of psychosocial variables to what was considered transmission risk behavior during the time of data collection. Since at that time, individuals were not making sexual decisions based on this knowledge, serodiscordant CAS was considered a behavior that could lead to HIV transmission. Consistent with this, a meta-analysis conducted during the same time period showed there was no difference in HIV acquisition risk behavior by viral load or ART status (Crepaz et al., 2009). We did not hypothesize that the psychosocial syndemics in this study would be differentially related to serodiscordant CAS based on viral load status, which was consistent with our test of possible moderating effects of viral load. Given that "Undetectable = Untransmittable" is in the process of being disseminated it will be important for future studies to re-evaluate the

relationship between syndemics and what is now considered sexual behavior that could lead to HIV transmission. The current study's findings can be used as a point of comparison for future studies conducted in the context of updated public health messaging. Additionally, this analysis did not distinguish risk based on sexual positioning; therefore, future studies would benefit from further analyses with consideration for both viral load and seropositioning to develop a more nuanced and current understanding of the relationship between these factors. Finally, as this was an analysis of the impact of syndemics on sexual behavior, we did not examine the associations between individual psychosocial concerns and CAS.

As a secondary analysis, this study's conceptualization of syndemics was limited to the initial set of measures that were collected for the larger study from which the data was drawn. CSA, a fixed past event, was only assessed at baseline as was PTSD. Social anxiety disorder was only assessed at baseline, however generalized anxiety and panic disorder were assessed at all time points, therefore anxiety scores varied over time. In future longitudinal research, it will be useful to continue expanding the syndemic factors that are observed longitudinally, including PTSD and distress related to CSA, which does vary over time. This will also facilitate developing and implementing interventions that can intervene upon all of the psychosocial syndemic conditions assessed, as distress related to CSA can be intervened upon, whereas developmental occurrences of CSA cannot be changed.

An ongoing area of discussion within the HIV-related syndemics literature is how to best operationalize and test syndemics theory. Some have suggested testing interaction terms between syndemic conditions to examine synergistic effects (Singer, Bulled, Ostrach, & Mendenhall, 2017; Tsai & Burns, 2015). Stall et al. (2015) suggest that although interaction effects may be tested, syndemics theory as it has been applied remains an essential part of syndemics theory, which has been widely supported by the literature. Testing numerous interaction terms could lead to detection of spurious effects without an a priori hypothesis about particular interactions and larger (up to 6-way interactions in this study) interactions may not lend themselves toward clinical utility. There have been mixed findings regarding interaction effects. Ferlatte et al. (2018) showed evidence of statistical interaction among syndemic conditions in predicting syphilis diagnosis among Canadian sexual minority men. Additionally, Storholm et al. (2016) found an interaction effect between depression and sexual compulsivity, such that sexual compulsivity's effects on sexual behavior was moderated by depression. In contrast, Morrison et al. (2018) did not detect interaction effects, which they interpreted to support the additive syndemics model. Tomori et al. (2018) found only one significant two-way interaction when testing 2- and 3-way interactions among five syndemic conditions associated with CAS among MSM in India. Accordingly, they suggest that the operationalization of syndemics be expanded to include cumulative models, which consistently show effects. Consistent with recent HIV-related syndemics studies with MSM (Friedman et al., 2015; Guadamuz et al., 2014; Mimiaga, Biello, et al., 2015; Mimiaga, O'Cleirigh, et al., 2015; Parsons et al., 2017; Tulloch et al., 2015), the present analysis shows evidence of disease concentration, as well as mutual causality between the syndemic conditions. We believe this approach provides clear public health and clinical implications, however, future research will continue exploring different approaches to conceptualizing and testing syndemics theory.

These findings point to further areas of research and practice. Engaging in serodiscordant CAS is a health behavior that is modifiable through behavioral intervention. A recent meta-analysis identified evidence-based interventions for reducing behaviors associated with risk of HIV transmission and highlighted that those that addressed mental health were more likely to be effective (Crepaz et al., 2014). Safren, Blashill, and O'Cleirigh (2011) pointed out that secondary prevention interventions need to be integrated with treatment of the co-occurring syndemic conditions that make it difficult to uptake safer sexual behaviors, as this will improve effect sizes of secondary prevention interventions. The present study's findings support this claim and suggest that tailoring behavioral interventions to meet the needs of those with higher levels of syndemic conditions may result in greater personal and public health benefit. Although provision of more intensive treatment to those who require it may be more costly in the short term, the long term benefits in terms of new infections averted would likely be cost effective (Safren et al., 2016; Safren, Perry, Blashill, O'Cleirigh, & Mayer, 2015). Further, this would improve the mental health of sexual minority men living with HIV, as well as their sexual health and that of their sexual partners.

Another potential implication for practice is to continue expanding the focus of secondary prevention programming beyond preventing transmission of HIV to new partners. Taking up safer sexual behaviors also benefits HIV-positive sexual minority men's own sexual health. For instance, condom use and disclosure of status and testing history can help this population to avoid reinfection or superinfection with a medication resistant strain of HIV as well as avoid infection with other STIs (World Health Organization, 2011). Focusing on the benefits of condom use and other sexual health behaviors for one's own health may be a useful strategy for reducing stigma and focusing on self-care in general. This broader approach to secondary prevention is consistent with what HIV-positive sexual minority men describe wanting in these types of interventions (Vanable et al., 2012). Additionally, Pachankis (2015) recommends that mental health providers conceptualize sexual health as including sex that is pleasurable, assertive, and positive. Clinicians are encouraged to take a clearly affirming stance regarding sexual minority men's expression of sexuality to address some of the minority stress pathways through which syndemic conditions develop. Taken together, this suggests the utility of multidisciplinary providers and institutions, including public health, medical providers, and mental health counselors affirming HIV-positive sexual minority men's sexuality broadly in order to optimize sexual health.

HIV-related syndemics research should also continue to expand and account for other co-occurring factors that may affect sexual health behaviors. Much of the syndemics research within MSM has focused on the intertwined psychosocial factors that heighten risk of HIV acquisition (Dyer et al., 2012; Mimiaga, Biello, et al., 2015; Mimiaga, O'Cleirigh, et al., 2015; Mustanski et al., 2007; Parsons et al., 2012, 2017; Ron Stall et al., 2003). However, structural and environmental factors are also facets of syndemics theory as originally articulated (Singer & Clair, 2003). For example, anti-gay discrimination and stigma, sexual orientation based violence, racism, and financial hardship are also part of the syndemic associated with CAS among MSM (Ayala, Bingham, Kim, Wheeler, & Millett, 2012; Duncan et al., 2017; Ferlatte et al., 2014; Mustanski et al., 2017). Similarly, life course events associated with stress and stigma are associated with the psychosocial syndemic conditions that have been shown to be associated with greater HIV-related behaviors among

MSM (Herrick et al., 2013). Continuing to incorporate these broader social determinants of health (i.e. stigma, heterosexism, marginalization, poverty, structural violence) in future studies examining syndemics among MSM will further bolster our knowledge of the individual, structural, and environmental syndemic conditions that perpetuate HIV-related health outcomes among MSM. Relatedly, using an intersectional lens instead of conceptualizing all sexual minority men living with HIV as one homogenous group can inform research on HIV-related syndemics, as multiple layers of identity and experience intersect to produce the social conditions that create these syndemics (Carnes, 2016). Future syndemics research should consider the unique syndemics that may occur and contribute to sexual health behaviors for subpopulations of sexual minority men across geographic region, race/ethnicity, age, and/or socioeconomic class. An intersectionality approach can inform tailored intervention to meet the needs of community members experiencing different networks of syndemic conditions that contribute to HIV-related health.

Although this study highlights the prevalence of these syndemic conditions and their impact on sexual health behavior, many sexual minority men living with HIV demonstrate resilience in the face of these stressors and take steps to protect their own and their partners' sexual health (Crepaz et al., 2009; McConnell, Bragg, Shiboski, & Grant, 2010). Capitalizing on the strengths and resilience of sexual minority men will be important in continuing efforts to move from a deficit based model of intervention and toward strengths based models (Herrick et al., 2011; Kurtz, Buttram, Surratt, & Stall, 2012). Identifying the protective factors that enable sexual minority men living with HIV to cope effectively with syndemic conditions in order to protect their own and their partners' sexual health can inform strengths-based interventions.

In conclusion, we found that multiple, co-occurring syndemic conditions are additively associated with greater likelihood of engaging in serodiscordant CAS among HIV-positive sexual minority men over a one-year period both comparing participants to each other, and within participants over time. In order to promote HIV-positive sexual minority men's sexual health and reduce onward transmission of HIV to uninfected partners, it will be important for researchers and clinicians to appreciate the contribution of these stressors to this population's sexual health behaviors. New interventions may be more effective by specifically addressing the multiple, overlapping factors that contribute to sexual health behaviors in this population.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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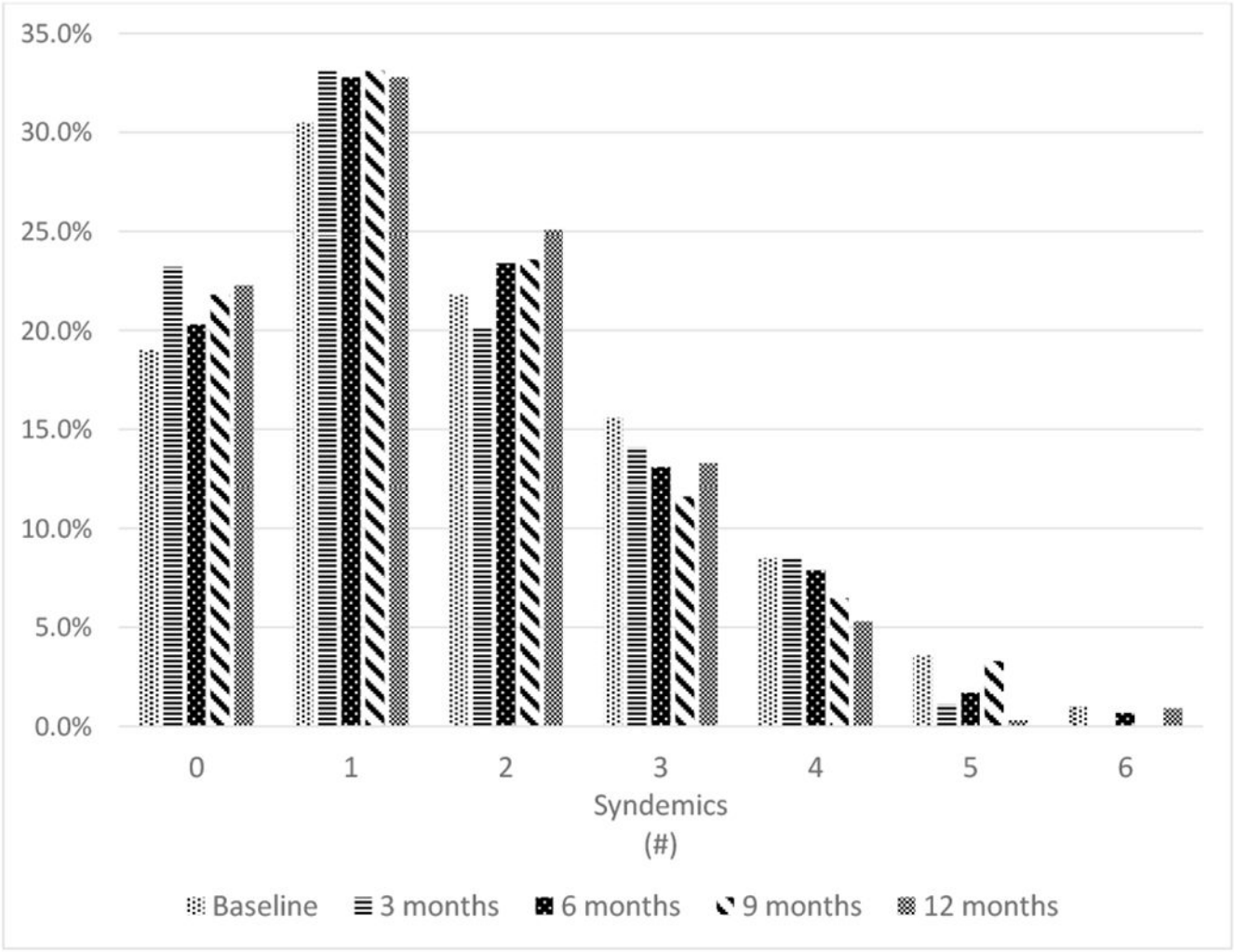

Figure 1.
Distribution of participants' syndemics scores at each visit.

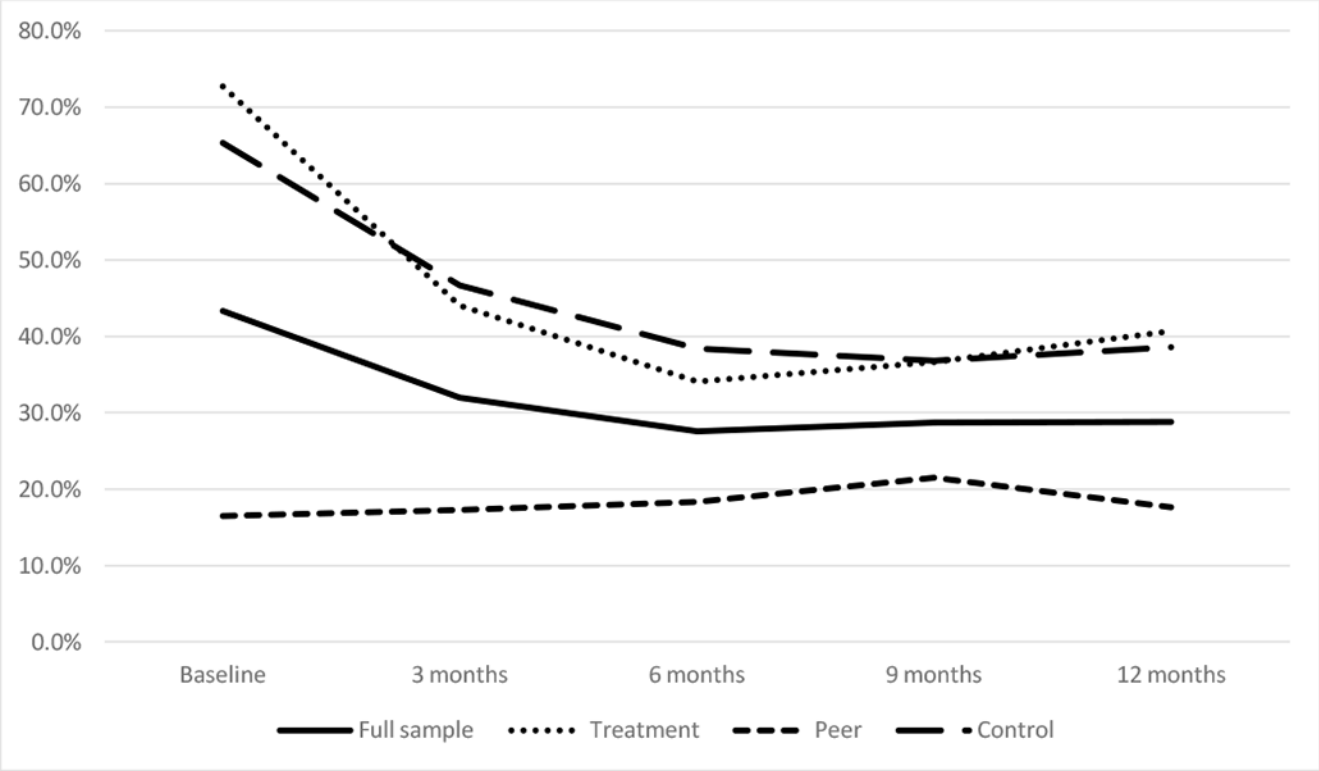

Figure 2.
Percentage of participants who reported serodiscordant CAS over time

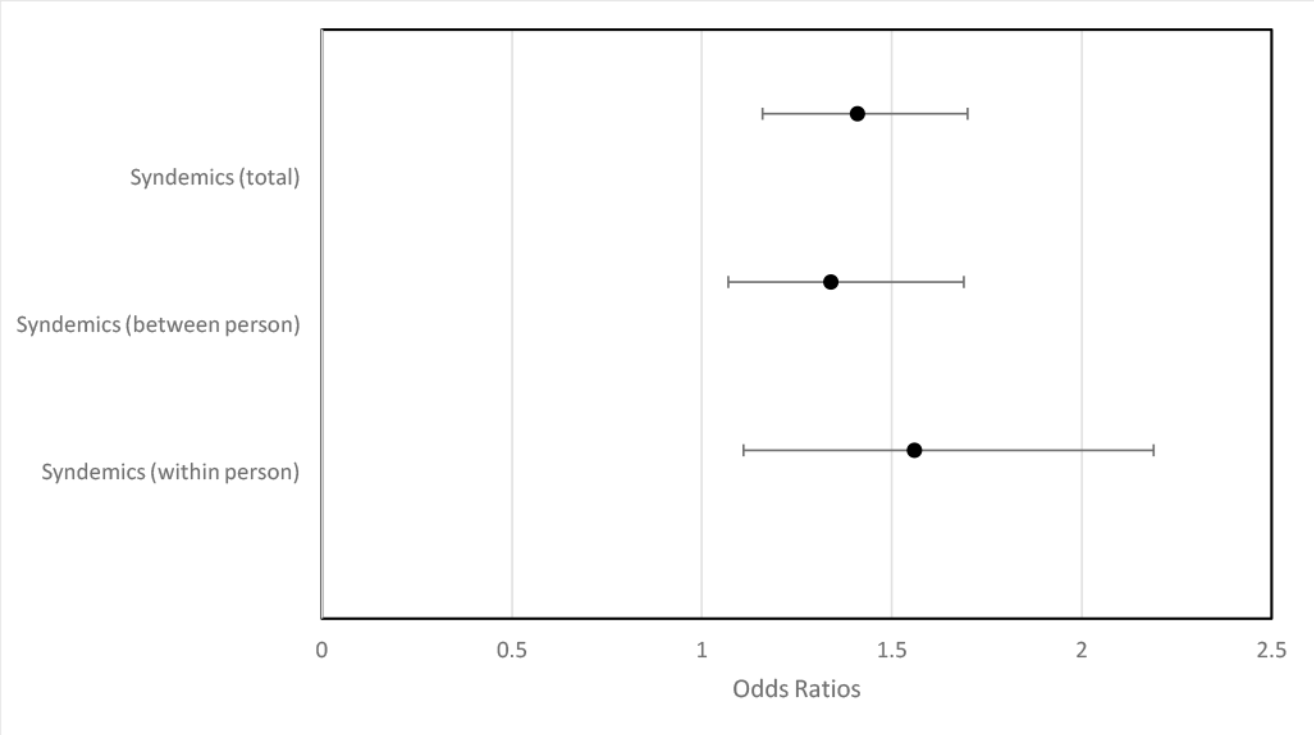

Figure 3.

Odds of CAS across predictors from Models 2 and 3

Note. The odds ratios refer to the increase in odds of serodiscordant CAS for a 1 unit increase in the continuous predictor. For syndemics, this refers to (1) Total: a one unit increase on the 0-6 total syndemics scores, (2) Between: a one unit increase in the person's average syndemics score across the 5 time points, and (3) Within: a one unit increase in the participant's deviation from their average score at a particular time point.

Table 1:

Results of multilevel models predicting CAS

Parameter	Model 1: Unconditional	Model 2: Syndemics total	Model 3: Syndemics disaggregated
Fixed effects			
Intercept *Estimate (SE)*	−1.19 (0.15) **	0.04 (0.35)	0.12 (0.37)
Time *Estimate (SE)*		−0.56 (0.13) **	−0.56 (0.13) **
Condition [a]		$F(2,806) = 35.22$ **	$F(2,806) = 35.42$ **
Experimental *OR (95% CI)*		1.19 (0.53-2.68)	1.18 (0.53-2.63)
Peer *OR (95% CI)*		0.08 (0.04-0.20) **	0.08 (0.04-0.19) **
Condition × Time [a]		$F(2,806) = 3.52$ *	$F(2,806) = 3.60$ *
Experimental *OR (95% CI)*		0.54 (0.42-0.71)	0.55 (0.42-0.71)
Peer *OR (95% CI)*		0.84 (0.64-1.12) *	0.85 (0.64-1.13) *
Syndemics *OR (95% CI)*		1.41 (1.16-1.70) **	
Between *OR (95% CI)*			1.34 (1.07-1.69) *
Within *OR (95% CI)*			1.56 (1.11-2.19) *
Random effects			
Intercept *Estimate (SE)*	4.87 (0.81)	4.07 (0.91)	4.06 (0.90)
Time *Estimate (SE)*		0.43 (0.17)	0.41 (0.17)

Note. Estimates are reported followed by standard errors in parentheses.

[a] Reference = control group.

* $p \leq .05$,

** $p \leq .01$