AIDS and Behavior (2023) 27:1824–1835
https://doi.org/10.1007/s10461-022-03914-z

ORIGINAL PAPER

Binge Drinking Moderates Unprotected Sex Among HIV Sero-Similar Same Sex Male Couples: An Actor-Partner Interdependence Model

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Accepted: 25 October 2022 / Published online: 28 November 2022

Abstract

Most new HIV diagnoses in the US occur among sexual minority men (SMM). The majority (69%) of new HIV diagnoses among US SMM are due to transmission from main sex partners. We identified multilevel correlates of unprotected anal intercourse (UAI; condomless anal intercourse while not using a biomedical strategy) among SMM couples using the Actor Partner Interdependence Model (APIM). Participants were US SMM over 18 years, with a primary male partner > 6 months. Couples were recruited online from April 2016 until June 2017 and interviewed using self-administered computer-assisted surveys. We used a series of APIM regressions to assess multilevel associations with UAI. We also tested the moderating role of an individual's binge drinking on the relationship between HIV status similarity and UAI. Among 798 participants (n = 411 couples), 61% reported UAI in the past 6 months. Binge drinking (52%) and physical intimate partner violence (IPV; 34%) were considerably high within our sample. Actor's binge drinking, reporting experiencing and/or perpetrating physical IPV, and partner's trust were positively associated with UAI. Actor having other sexual partner(s), using illegal drugs (not marijuana), and length of relationship were negatively associated with UAI. Binge drinking positively moderated UAI among HIV serostatus similar partners. HIV prevention programming should integrate components on IPV and binge drinking reduction- especially among HIV serostatus similar couples.

Keywords HIV · Actor-Partner Interdependence Model · Sexual minority men · Dyadic analysis · Alcohol use

Introduction

Gay, bisexual, and other sexual minority men (SMM) continue to be a group at highest risk of HIV in the US [1]. In 2019, SMM accounted for 69% of the ~ 36,000 new HIV infections- and estimates suggest that 1 in 6 SMM will be diagnosed with HIV in their lifetime [2]. Modeling work has indicated that the majority (69%) of new HIV diagnoses among US SMM are due to transmission from their main sex partners, and although these models are now 10 years old and may need to be updated taking into account recent advances in biomedical prevention, this illustrates that an individual's HIV vulnerability is directly related to their main partner, and the context of their relationship [3]. Relationship dynamics including love [4–7], trust [8], and power dynamics including intimate partner violence (IPV) [9, 10], have previously been established to play a role in HIV vulnerability within SMM couples as relationship context can establish the use of biobehavioral prevention strategies and condoms, shaping perceptions of risk within relationships [11].

Biobehavioral prevention strategies for HIV such as pre-exposure prophylaxis (PrEP) and Undetectable = Untransmittable (U = U) through antiretroviral treatment (ART), have remarkedly reduced HIV transmission among SMM, including transmission between primary partners [12, 13]. PrEP and ART can be integrated with

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other prevention strategies, including HIV testing, status disclosure (i.e., HIV status, PrEP status, undetectable status), and condom use, to reduce risk of HIV transmission. Although previous research has shown that SMM use status information to guide decisions around condom use and sexual behavior (e.g., serosorting, biomed matching, biomed sorting) [11, 14–16], individuals may not disclose their PrEP or ART use to their sexual partners [17–19]. "Sero-sorting" involves selecting a partner who is sero-similar in HIV status, "biomed matching" is a prevention strategy in which both partners use PrEP, and "biomed sorting" is when one partner uses PrEP and another uses ARTs [17, 18, 20]. Among SMM, serosorting, biomed matching, and biomed sorting have previously been shown to be associated with lower likelihood of condom use between sero-similar SMM partners [17, 21, 22]. SMM who reported PrEP use and high rates of condomless sex have also reported suboptimal adherence to the biomedical strategy, effectively increasing vulnerability to HIV acquisition from their primary partner [23]. With the increasing availability of PrEP [14, 15], researchers have posited that aspects of sexuality have changed for SMM and that the "new era of biobehavioral HIV prevention," should be considered when considering sexual behavior, such as condomless sex [24]. This sentiment can also potentially be expanded to U = U.

Condomless sex allows SMM to express love, intimacy, and trust with their primary partner, while facilitating relationship strength [4–7]. For this, sero-sorting, biomed sorting, and biomed matching can be opportunities for SMM in partnerships to enhance their relationship quality while practicing HIV risk reduction behaviors. Previously identified barriers to practicing HIV risk reduction behaviors, including condom use, are binge drinking and substance use [25, 26]. At the individual level, SMM who reported binge drinking were more likely to report condomless anal sex with someone with a different HIV serostatus [25]. At the dyadic level, binge drinking of either dyad has previously been associated with both living with HIV and higher relationship quality (i.e., feeling more loved in a relationship), suggesting that homophily may play a role in unprotected anal sex (UAI; i.e., condomless anal intercourse while either dyadic member was not using a biomedical strategy) [26]. In addition, IPV has been found to be associated with condomless anal sex [9] and with decreased ability for SMM to negotiate condom use within their primary partners [10].

Social network analyses explore the role of social relationships in enabling behavior, such as condomless sex [21]. In social network analyses, individuals can be contextualized within their immediate social network, including their primary partnership. It is important to consider an individual within a primary partnership as the social network theory of Behavioral Contagion suggests that behaviors, such as binge drinking or HIV outcomes, can "spread" within a network or partnerships [27]. However, homophily, the phenomena in which individuals are attracted to and connect with others who are similar to them in basic characteristics and attributes [28], has been shown to explain over 50% of perceived behavioral contagion [29]. This suggests that instead of peer influence accounting for the uptake of new behaviors, behaviors (i.e., alcohol use) and characteristics (i.e., HIV status) may instead be due to similarities among dyads [29, 30]. Other studies have suggested that relationship characteristics, such as interpersonal trust and IPV could influence condomless sex, due to their sexual negotiation [31] or a lower likelihood to engage in condom negotiations [10]. SMM who have a main partnership may believe their HIV risk to be low; however within partnerships, SMM with an open sexual agreement were more likely to have tested for HIV in the past six months [32]. Thus, it is important to consider the relational context (e.g., open or closed relationship) of SMM to understand HIV vulnerability within established relationships.

Presently, there is no definitive consensus on the role of binge drinking on serosorting, biomed sorting, or biomed matching on UAI. At the dyadic level, previous research offers mixed findings on the influences of partner's substance use and hazardous alcohol consumption on SMM's HIV vulnerability. For example, one study found that if an individual's partner used stimulants, HIV outcomes were poorer [33]; however, another study found that if an individual's partner abstained from alcohol, HIV outcomes were poorer [34]. There is a gap in the literature regarding the relationship between serosorting and UAI; and the potential moderating role of individual-level binge drinking on sero-sorting and subsequent UAI. A meta-analysis found that alcohol use is associated with greater intentions to engage in condomless sex [35]. However, it is unknown if SMM would engage in UAI with their primary partner who may be sero-different. Several studies have agreed that alcohol generally increases sexual vulnerability to HIV [35]; however the influence of alcohol use on condom use during sex is complex and not straightforward, especially in established primary partnerships [36]. This study aims to characterize individual, dyadic, and partner-level associations on UAI among same sex male couples (i.e., couples in a primary partnership). We used the Actor-Partner Interdependence Model (APIM), which accounts for the interdependence within dyads (i.e., same sex male couples) to explore the moderating role of serostatus

similarity on binge drinking when examining UAI within same sex male couples [37, 38]. In the present study, we operationalize UAI as a proxy for HIV transmission risk within the partnership. We hypothesize that there will be an association between actor and partner binge drinking and UAI among same sex male couples, and that actor's binge drinking will have a moderating role on UAI based on HIV status similarity.

Methods

Study Population

Data were from the baseline assessment of the longitudinal NEXUS intervention study and were collected between April 2016 and June 2017. As described in detail elsewhere [39], participants were recruited through online advertisements placed on key social networking sites (i.e., Facebook and Instagram). To be eligible for the study, participant inclusion criteria included (1) reporting being a cisgender man (assigned male sex at birth and currently identify as a man); (2) reporting being age 18 years or older; (3) living in the US; (4) having home internet access; and (5) willing to receive home-based couples HIV test kits at a chosen address. At the dyadic level, inclusion criteria included (1) the relationship being established for at least 6 months, (2a) for HIV negative sero similar couples not having been tested for HIV in the past 3 months or (2b) for sero different couples the HIV negative partner not testing for HIV in the past 6 months; (3) and no acts of IPV in the past year. Participants individually (i.e., without their partner) provided written informed consent online and self-administered a quantitative assessment using Qualtrics which took approximately 1–2 hours to complete.

Measures

Sociodemographic and background characteristics: Participants provided information about their age, race and ethnicity (non-Latino/x White, Latino/x, non-Latino/x Black, non-Latino/x other), education (high school, some college, college degree, post-graduate), state of residency, and employment status (full-time, part-time, unemployed, other). Participants self-reported their HIV serostatus (negative, positive, or doesn't know), current PrEP use if HIV negative, and viral load suppression if living with HIV (suppressed or not suppressed). Additionally, participants self-reported relationship length.

Drug and alcohol consumption: Participants reported binge drinking by indicating if they had 6 or more drinks on one occasion in the past 3 months, using an item from the Alcohol Use Disorders Identification Test (AUDIT-C) [40]. Participants reported illicit substance use by indicating use of one of the following drugs in the past 3 months if they were not prescribed: amphetamine, downers (Valium, Ativa, Xanax), pain killers (Oxycontin, Percoset), hallucinogens, ecstasy, club drugs (GHB, ketamine), crack, cocaine, and/or heroin.

Relationship-level characteristics*:* Participants indicated if they had anal sex with a man other than their primary partner in the past 3 months (other sexual partners) and their trust in their primary partner as assessed by the Dyadic Trust Scale [8]. Reporting the same relationship "status" was assessed by first asking participants to characterize the relationship [husband, boyfriend, partner, other (i.e., fuck buddy, hook up)] then identifying concordance on relationship status at the dyadic level. Homophily on HIV serostatus was calculated as HIV sero-similar (either both partners reported being HIV negative or both partners reported living with HIV), HIV sero-different (either both partners do not know their HIV serostatus, one partner does not know their HIV status, or one partner is HIV negative and the other partner is living with HIV). Although reports of IPV in the past year served as an exclusion criterion, we assessed ever having experiences of physical IPV using the four item Physical Violence subscale of the Gay and Bisexual Men Intimate Partner Violence Scale [41]; and recoded as reporting no lifetime IPV, victim of lifetime IPV, perpetrator of lifetime IPV, and both victim and perpetrator of lifetime IPV within the partnership.

Outcome of UAI Participants provided information about their biomedical prevention strategy based on their HIV serostatus. HIV-negative participants were asked if they were currently using PrEP. Participants living with HIV were asked if they were virally suppressed. Additionally, participants indicated if they used condoms consistently with their primary partner in the past 6 months. To calculate UAI we assessed three variables at both the individual and dyadic level. We operationalized UAI in the past 6 months if (1) the participant was not using PrEP or adherent to their HIV treatment, and/or if (2) the participant reported having condomless anal sex within the past 6 months with their primary partner who was either HIV status unknown/HIV negative and not using PrEP or HIV positive and reported not being adherent to their HIV treatment or virally suppressed. Additional information surrounding the actor's conferral of protection during condomless sex can be found in Table 1.

Table 1 Conferral of protection during condomless sex

			Actor			
			HIV −		HIV +	
			Adherent to PrEP	Not adherent to PrEP	Adherent to ART	Not adherent to ART
Partner	HIV −	Adherent to PrEP	Protected	Protected	Protected	Protected
		Not adherent to PrEP	Protected	Unprotected	Protected	Unprotected
	HIV +	Adherent to ART	Protected	Protected	Protected	Protected
		Not adherent to ART	Protected	Unprotected	Protected	Unprotected

Statistical Analysis

We calculated Spearman's rank correlation coefficients for each pair of variables in our model to ensure correlations were below 0.5. We used the APIM to examine correlates of UAI in three models: an unadjusted model, a full model without interaction effects, and a full model with interaction effects. APIM allows for the consideration of both partner's effects on an outcome and accounts for interdependencies within dyads. Because our dyads are same gender male couples, they are indistinguishable (relative to male–female couples which are distinguishable). We used binomial generalized linear mixed effect modeling, which allowed for interdependence within the dyad when examining the binary outcome variable of UAI [42, 43]. The binomial generalized linear mixed effect model also allowed us to include fixed effects at the actor, partner, and dyadic levels, while including the dyad as a random effect. We assessed the relationship between actor-level variables (i.e., actor had other sexual partners, actor reported lifetime IPV, actor binge drank, actor used illicit drugs, actor's trust for partners, actor's reported relationship length) and relationship-level variables (i.e., both actor and partner reported same relationship status, actor and partner HIV status homophily, partner binge drank partner used illicit drugs, partner's trust for actor) on the outcome variable of UAI at the actor level. We tested the moderating role of actor's binge drinking on the relationship between HIV status similarity (i.e., serosorting) and UAI in our regression models. Then, we conducted a simple slope analysis to assess the association between binge drinking and UAI among participants, stratified by HIV status similarity. The R package "lme4" was used to conduct analyses. Only complete cases were included in our final analyses.

Ethics

Ethical approval for the present study was approved by the University of Michigan Institutional Review Board (HUM00182640).

Results

Descriptive Information

A total of 798 participants in 411 dyads were included in our analyses. Participants were a mean age of 30 years, majority non-Latino/x White (65%), gay (91%), employed full-time (68%), and HIV negative (86%). The majority of couples reported HIV sero-similar status (77%). The majority of participants reported not using illicit drugs (87%) and being in a partnership in which both partners did not use illicit drugs (79%). Slightly over half of participants reported binge drinking in the past 3 months (52%) and 61% of participants were in a relationship in which at least one of the dyads reported binge drinking in the past 3 months. The majority of participants were in the relationship for either 6 months to 2 years (36%) or 2–5 years (34%), reported high levels of interpersonal trust for their partner (mean score = 20; range = 1–26), and engaged in UAI (61%). The majority of couples (84%) reported being in a relationship in which both partners reported the same relationship status. Of participants, 87% reported having another sexual partner and 33% reported lifetime physical IPV within the partnership. Participants were from 46 states (no participants were from Alaska, Montana, New Hampshire, and Rhode Island). The three most represented states were Texas (n = 81, 9.4% of sample), California (n = 74, 8.6% of sample), and Florida (n = 57, 6.6% of sample). There were no correlations between variables above 0.4, with additional details on Spearman correlation coefficients between variables in Appendix 1. Additional information can be found in Table 2.

Results of the Unadjusted APIM Analysis

We found the intraclass correlation of the null model to be 0.10, signifying that 10% of the variation in UAI

Table 2 Actor and dyadic level background information

	Overall (N = 798)
Age	
Mean (SD)	30.2 (8.98)
Median [Min, Max]	28.0 [18.0, 68.0]
Race and ethnicity	
Non-Latino/x White	518 (64.9%)
Latino	156 (19.5%)
Non-Latino/x Black	47 (5.89%)
Another non-Latino/x racial identity	77 (9.65%)
Sexual identity	
Gay	729 (91.4%)
Bisexual	52 (6.52%)
Queer	14 (1.75%)
Questioning/Unsure	3 (0.376%)
Employment status	
Full-time	544 (68.2%)
Part-time	128 (16.0%)
Another employment status	58 (7.27%)
Unemployed	57 (7.14%)
Disability	11 (1.38%)
Relationship type	
Boyfriend or fiancée	351 (44.0%)
Husband or spouse	262 (32.8%)
Partner	169 (21.2%)
Another relationship type*	16 (2.0%)
Relationship length	
6 months to 2 years	287 (36.0%)
2–5 years	274 (34.3%)
5–10 years	153 (19.2%)
More than 10 years	84 (10.5%)
HIV serostatus	
Doesn't know	97 (12.2%)
Negative	684 (85.7%)
Positive	17 (2.13%)
Illicit drug use in past 3 months	
No	691 (86.6%)
Yes	107 (13.4%)
Binge drinking in past 3 months	
Never	387 (48.5%)
Binge drank	411 (51.5%)
Has other sexual partner(s)	
No	139 (17.4%)
Yes	659 (82.6%)
Lifetime physical IPV with current partner	
None	554 (66.2%)
Both victim and perpetrator	131 (16.4%)
Perpetrator only	52 (6.52%)
Victim only	74 (9.27%)
Interpersonal trust	
Mean (SD)	19.6 (5.22)
Median [Min, Max]	20.0 [1.00, 26.0]
Relationship status concordance	
Concordant on relationship status	344 (83.7%)
Discordant on relationship status	67 (16.3%)
HIV status similarity	
Sero-similar	318 (77.4%)
Sero-different or one partner didn't know status	93 (22.6%)
Binge drinking concordance	
Both did not binge drink	162 (39.4%)
Both partners binge drank	147 (35.8%)
One partner binge drank	102 (24.8%)
Illicit substance use concordance	
Both partners did not use illicit drugs	323 (78.6%)
Both partners used illicit drugs	24 (5.84%)
One partner used illicit drugs and one partner did not use illicit drugs	64 (15.6%)
Unprotected anal intercourse	
Protected anal intercourse only	314 (39.3%)
Unprotected sex	484 (60.7%)

*Another relationship types included "lover," "inseparable," "I don't know," "friend with benefits," "we don't use labels," "figuring things out," "best friend and favorite person"

was due to the relationship level. In the unadjusted model, we found that the actor being both a victim and perpetrator of lifetime physical IPV (OR = 1.88, 95% CI: 1.19–2.98, p = 0.007), the actor reporting binge drinking in the past three months (OR = 1.48, 95% CI: 1.07–2.05, p = 0.016), and the partner's interpersonal trust (OR = 1.04, 95% CI: 1.01–1.07, p = 0.018) were significantly and positively associated with UAI. We also found that participants who reported being in a relationship for over 10 years (relative to 6 months to 2 years; OR = 0.44, 95% CI: 0.25–0.79, p = 0.006) and in a HIV sero-different relationship or a relationship in which one partner did not know their HIV status (relative to a serostatus similar relationship; OR = 0.63, 95% CI: 0.43–0.93, p = 0.02) were significantly and negatively associated with UAI. Additional information about the results of our bivariate analyses can be found in Table 3: Unadjusted model.

Results of the APIM Analysis Without Interaction Effect

At the actor-level, participants who reported having other sexual partners (OR = 0.63, 95% CI: 0.41–0.98, p = 0.042) and a relationship of over 10 years (OR = 0.45, 95% CI:

0.25–0.81, p = 0.008) were less likely to report UAI with their main partner in the last 3 months. At the actor-level, participants who reported being both a victim and perpetrator of lifetime physical IPV (relative to reporting no lifetime physical IPV; OR = 2.15, 95% CI: 1.32–3.53, p = 0.002) were more likely to report UAI. At the partner level, the partner's trust for the actor was significantly and positively associated with UAI in the past 3 months (OR = 1.05, 95% CI: 1.02–1.08, p = 0.003).

Results of the APIM Analysis with Interaction Effect

At the actor-level, participants who reported having other sexual partners (OR = 0.64, 95% CI: 0.41–1.00, p = 0.048) and a relationship of over 10 years (OR = 0.46, 95% CI: 0.25–0.83, p = 0.01) were less likely to report UAI with their main partner in the last 3 months. At the actor-level, participants who reported being both a victim and perpetrator of lifetime physical IPV (relative to reporting no lifetime

Table 3 Individual and dyadic associations on unprotected sex among SMM in same sex partnerships, n = 798

	Unadjusted model: UAI			Full model without interaction effects: UAI			Full model with interaction effects: UAI		
	Odds Ratios	*CI*	*p*	*Odds Ratios*	*CI*	*p*	*Odds Ratios*	*CI*	*p*
(Intercept)				0.41	0.15–1.15	0.091	0.39	0.14–1.08	0.069
Actor-level variables									
Actor had other sexual partners	0.73	0.47–1.12	0.137	0.63	0.41–0.98	**0.042**	0.64	0.41–1.00	**0.048**
Actor reports lifetime IPV (ref = No physical lifetime IPV)									
Both victim and perpetrator of lifetime physical IPV	1.88	1.19–2.98	**0.007**	2.15	1.32–3.53	**0.002**	2.1	1.28–3.45	**0.003**
Perpetrator of lifetime physical IPV	1.24	0.65–2.35	0.518	1.48	0.77–2.86	0.24	1.48	0.76–2.86	0.246
Victim of lifetime physical IPV	1.44	0.83–2.52	0.194	1.59	0.90–2.80	0.11	1.57	0.89–2.77	0.12
Actor binge drank	1.48	1.07–2.04	**0.016**	1.3	0.92–1.84	0.132	1.59	1.07–2.37	**0.022**
Actor used illicit drugs	0.7	0.44–1.12	0.136	0.63	0.39–1.04	0.07	0.63	0.38–1.03	0.065
Actor's trust for partner	1.02	0.99–1.05	0.168	1.03	1.00–1.06	0.074	1.03	1.00–1.06	0.067
Relationship length (ref = 6 mos–2 years)									
2–5 years	1.19	0.80–1.75	0.388	1.13	0.76–1.67	0.55	1.13	0.77–1.68	0.535
5–10 years	0.98	0.62–1.55	0.941	1.03	0.65–1.63	0.91	1.02	0.64–1.61	0.948
10 + years	0.44	0.25–0.79	**0.006**	0.45	0.25–0.81	**0.008**	0.46	0.25–0.83	**0.01**
Relationship-level variables									
Both did not report same relationship status	1.2	0.76–1.87	0.436	1.19	0.76–1.87	0.441	1.17	0.75–1.83	0.494
HIV sero-different or at least one partner doesn't know status (ref = HIV serostatus similar)	0.63	0.43–0.93	**0.02**	0.61	0.41–0.90	**0.013**	0.89	0.52–1.50	0.656
Partner-level variables									
Partner binge drank	1.28	0.94–1.76	0.122	1.13	0.80–1.60	0.479	1.10	0.78–1.56	0.578
Partner used illicit drugs	0.92	0.58–1.45	0.712	0.9	0.55–1.46	0.663	0.90	0.55–1.48	0.691
Partner's trust for actor	1.04	1.01–1.07	**0.018**	1.05	1.02–1.08	**0.003**	1.05	1.01–1.08	**0.004**
Interaction effects									
Actor's binge drinking X HIV status homophily (ref = HIV sero-different or one partner does not know HIV status)							0.46	0.22–0.98	**0.043**
Random effects									
σ^2				3.29			3.29		
$\tau_{00\ dyad}$				0.23			0.31		
ICC				0.06			0.09		
N_{dyad}				411			411		
Observations				798			798		
Marginal R^2 / Conditional R^2				0.084 /0.143			0.095/0.172		

physical IPV; OR = 2.10, 95% CI: 1.28–3.45, p = 0.032) and binge drinking in the past three months (OR = 1.59, 95% CI: 1.07–2.37, p = 0.022) were more likely to report UAI. At the dyadic level, although the full model without the interaction effect found that participants who were in relationships that were sero-different were less likely to report UAI with their main partner in the past 3 months, this effect disappeared when the interaction effect of actor's binge drinking and HIV status similarity was introduced into the analysis. At the partner level, the partner's trust for the actor was significantly and positively associated with UAI in the past 3 months (OR = 1.05, 95% CI: 1.01–1.08, p = 0.004). There was a statistically significant interaction effect between actor's binge drinking and HIV status similarity, which resulted in a lower likelihood of UAI with main partner in the last 3 months (OR = 0.46, 95% CI: 0.22–0.98, p = 0.043). The model with the interaction effects was found to be a statistically better fit to the data compared to the model without the interaction effects ($\chi^2 = 5.66$. p = 0.017). Additional information about model results can be found in Table 3.

Probing and Plotting the Interaction Effect

The simple slope analysis found that there was no significant difference between participants based on HIV status similarity among participants who did not report binge drinking in the past 3 months (Est = − 0.05, S.E. = 0.26, p = 0.85). However, the simple slope analysis found that there was a significant difference between participants based on HIV status similarity among participants who reported binge drinking in the past 3 months (Est = − 0.93, S.E. = 0.27, p = 0.00). Figure 1 displays the plot of the predicted probability of UAI, stratified by binge drinking and HIV sero-similarity. We found that of participants who reported binge drinking in the past 3 months, the probability of UAI was significantly higher among participants who were in a sero-similar relationship (Prob = 0.74), relative to participants who were in an HIV sero-different relationship or if one partner did not know their HIV status (Prob = 0.52). Among participants who did not binge drink in the past 3 months, there was no difference between UAI among participants based on HIV sero-similarity.

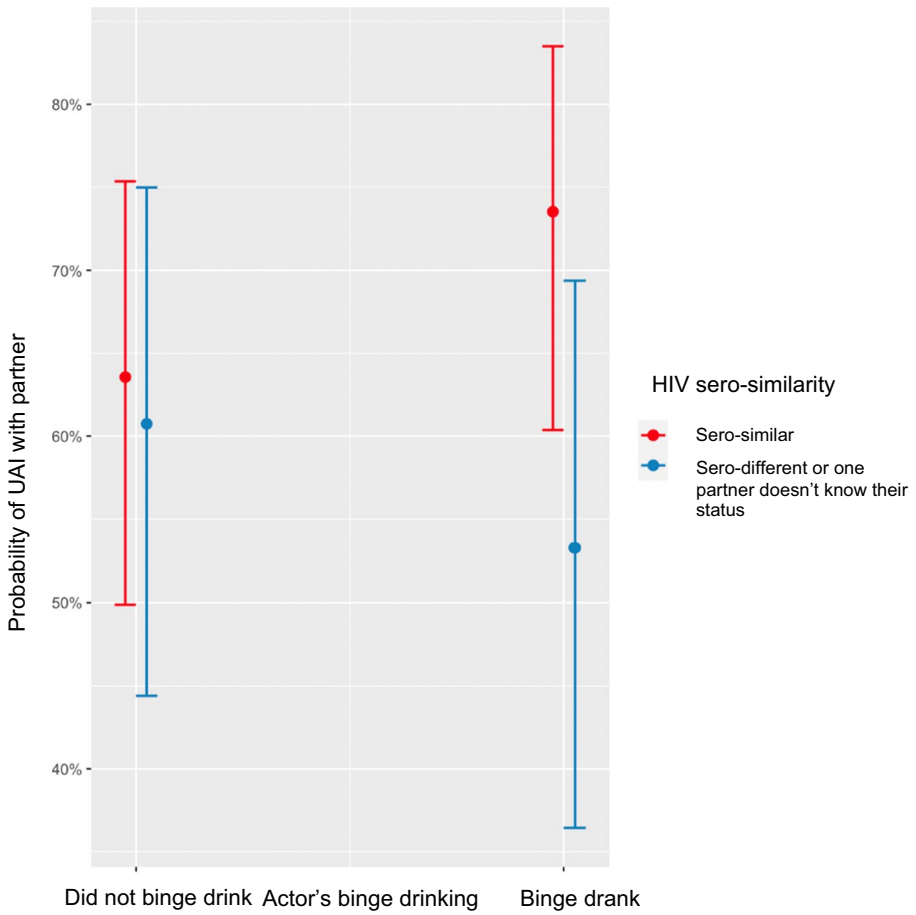


Fig. 1 Predicted probability of UAI, based on actor's binge drinking and HIV serostatus similarity

Discussion

Using the APIM, we sought to identify how actor- and relationship-level characteristics were associated with UAI in a dyadic study of SMM. Our hypotheses were partially supported: partner's binge drinking was not associated with UAI although actor's binge drinking was. Additionally, binge drinking moderated the role of serosorting on the outcome of UAI. Our study is novel and unique because it considers sexual behavior within the context of biomed matching through the variable construction of UAI. Binge drinking was considerably high (52%) within our sample and considerably higher than rates reported nationally for men [44] and SMM [26, 45–47]. Of participants, over 75% reported the same binge drinking behaviors of their partners. Actors who reported other sexual partners and longer relationship duration experienced a lower likelihood of UAI with their primary partner. In contrast, actors who reported being both a victim and perpetrator of physical IPV reported higher likelihood of binge drinking in the past three months and actors whose partners had higher interpersonal trust for them reported a higher likelihood of UAI with that primary partner. Most notably, we found that binge drinking moderated the association between HIV sero-similar SMM couples and UAI: SMM who reported binge drinking had higher likelihood of UAI if they had a sero-similar partner. Among SMM who reported binge drinking, the probability of UAI was significantly higher among SMM in sero-similar relationships relative to SMM in sero-different relationships.

Interestingly, and contrary to a previous study with heterosexual couples [30], we found that partner's binge drinking was not associated with UAI for SMM. Of note, all participants who are HIV negative and have a partner living with HIV had not been tested for HIV within the past 6 months, and participants who are HIV negative and have an HIV negative partner had not been tested for HIV within the past 3 months. Among all participants, 85% reported having outside partners in the past 3 months. This is alarming as SMM may acquire HIV from sex outside partnerships and then inadvertently transmit HIV to their primary partner. Previous research has found that those SMM who report being in a sero-similar relationship perceive their risk of acquiring HIV as low but serosorting may actually amplify HIV risk in areas with low HIV testing [48]. As the CDC recommends that SMM test for HIV every 3–6 months [49], and our sample was a group of SMM who may be at elevated sexual vulnerability to HIV, our findings support a need to provide expanded HIV testing options to address the testing preferences of those SMM who had not recently tested. This also highlights the limitations of serosorting as an effective prevention strategy for HIV negative men. Thus, those participants who assumed they were either HIV negative or in HIV negative sero-similar relationships may actually have been in sero-different relationships. Future interventions can consider how to provide guidance on sero-sorting, biomed sorting, and biomed matching in a non-stigmatizing manner.

We found that the positive association between binge drinking and condomless sex was only significant among SMM in relationships in which both partners perceived their HIV status to be negative. Binge drinking and hazardous alcohol use are risk factors for condomless sex and recent evidence has suggested that alcohol may strengthen sexual arousal which increases condomless sex, for more pleasureful sex [50]. Sexual health interventions should be centered around pleasure, a long missing key to unlocking HIV intervention successes [51, 52]. With the availability of PrEP and ART (U = U), the dialogue of pleasure can be introduced into HIV prevention strategies. Ultimately, HIV protection is not conferred through the dichotomy of consistent condom use, but through numerous intricate situations in which individuals could choose to either consistently use condoms, engage in serosorting, biomed matching, and biomed sorting, and use or adhere to biomedical prevention strategies. Thus, individuals' HIV vulnerability must be considered within the context of biomed matching or sorting [17, 18, 20]. However, participants in our study were in established relationships in which both individuals knew of their partner's HIV status, signifying that SMM are not consciously making a decision to sero-sort but rather be actively engaged in a relationship with someone with someone they know the status of. When individuals binge drink, they may experience behavioral disinhibition, such as sensation seeking, which can then moderate condom use during sex within sero-similar relationships [53]. Alternately, binge drinking may decrease risk perceptions which can result in condomless sex [36]. To address this, interventions can prioritize the utility of synthesizing components such as biomedical strategies, novel HIV testing approaches, and binge drinking reduction, with tailoring for sero-similar couples. An opportunity to engage HIV negative SMM could be to provide wrap-around services to partners if one partner receives HIV prevention services, such as what is done with partners of people living with HIV [54]. For example, Couples HIV Testing and Counseling could engage SMM couples [55], and provide an entry to HIV prevention and binge drinking reduction service

provision using a status neutral care approach [56]. Prevention options for people who test negative could then include linkages to acceptable long-acting HIV prevention options such as injectable or nonvisible implantable PrEP, as these strategies can confer protection for up to three months post-injection and not be greatly affected by binge drinking [57–59]. Essentially, interventions for same sex SMM couples must prioritize the user, and center their unique needs, providing only those services which are acceptable and integrable in daily life.

Our study also found that relationship context such as trust and IPV was associated with condomless sex. Trust is dynamic, and is associated with sexual risk taking (i.e., condomless sex) within the relationship [60]. Trust among SMM has previously been established based on sexual agreements and can play a role in navigating condom use during sex [60]. Trust can often also outweigh efforts to discuss HIV prevention strategies, such as condom use during sex [61]. Future interventions among SMM same sex couples should consider the use of prompts or reminders to discuss HIV prevention strategies throughout the relationship, despite trust levels or relationship length. SMM who reported being both a victim and perpetrator of lifetime physical IPV were at higher risk of UAI relative to those with no prior reports of lifetime IPV within the couple. SMM who report physical or emotional IPV within their partnership may be living in environments with immediate and emotional harm, which can turn into a violent situation if they refuse condom use with their partner. This could be because men in relationships with a history of IPV may not have the power to promote condom or PrEP use, or even provide consent for sex, emphasizing the importance of self-efficacy in condom and sexual negotiations [10, 31, 60, 62]. Additionally, IPV has been shown to be associated with minority stresses such as homophobic discrimination, suggesting that multilevel structural influences can negatively impact relationships [9]. Although interventions can consider how to mitigate homophobia and IPV at the individual level, these could better be addressed at the structural level. Instead of using cross-sectional research to examine IPV (51), future research can focus on prospective longitudinal data collection to understand how modifiable individual level risk factors (i.e., poor behavioral control, lack of nonviolent social problem-solving skills, and heavy alcohol and drug use) and relationship factors (i.e., history of experiencing childhood abuse, addressing relationship conflicts, etc.) can be integrated into comprehensive HIV prevention interventions for SMM.

Limitations

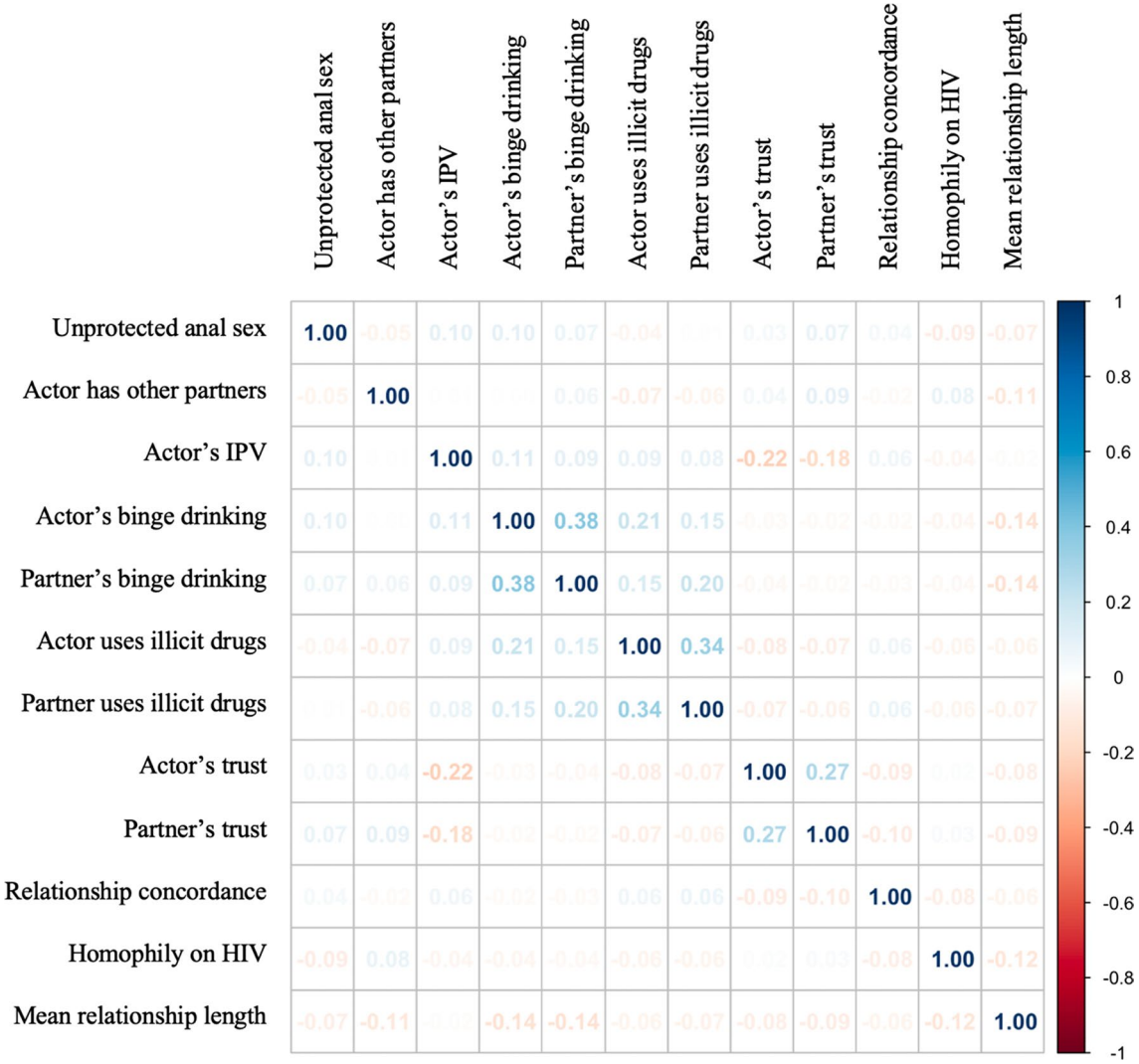
Limitations of this study include self-report, information, social desirability, and recall bias. Some of these biases may have limited the reporting of stigmatized behaviors. Second, our sample of couples was recruited using convenience sampling methods through social media only; thus, our results are not generalizable to all SMM in same sex male couples. Third, our recruitment criteria required both partners be enrolled, which reduced the number of couples in which one partner may be apprehensive about discussing sexual health and relationship factors, such as IPV. Fourth, through our calculation of UAI, we made an assumption that participants' current biomedical strategy was the strategy being used at the time of sex; however, participants' biomedical prevention strategy may not have been the same at the time of sex. Further, we did not collect information regarding PrEP adherence. Finally, we used reports of IPV in the past year as an exclusion criterion: IPV is an established risk factor for UAI within relationships and the inclusion of participants who reported IPV in the past year could have produced different results. Despite IPV in the past year being an exclusion criterion, we found that 34% of our participants reported lifetime IPV. This suggests that participants either have a history of IPV which discontinued within the past year, experienced IPV recently (i.e., from the point of recruitment screening to research enrolment), or that there was inconsistent reporting between recruitment screening and research enrolment.

Conclusions

We described UAI as a proxy for HIV transmission risk within the partnership. We found that SMM who reported having other sexual partners and were in longer term relationships had decreased HIV transmission vulnerability from their primary partnership, from which 69% of new HIV infections among SMM are acquired. SMM who reported IPV and recent (in the past 3 months) binge drinking had increased HIV transmission risk from their primary partnership. We also found that partner's trust increased HIV transmission risk. Binge drinking played a moderating role on HIV serostatus: individuals in relationships with someone who had the same HIV status as him were more likely to engage in UAI if they reported binge drinking. HIV prevention programming among same sex primary partners should address IPV and binge drinking because they were identified as important drivers of HIV transmission risk.

Appendix 1

Correlation plot of variables of interest



Author Contributions RS, JK, CS, and RM conceptualized the design of the analysis. RS coordinated the collection of the data then contributed the data for this manuscript. CHS and JK performed the analysis. All authors contributed to writing, editing, and proofreading the manuscript. All authors approved the final manuscript.

Funding The research leading to these results received funding from the Eunice Kennedy Shriver National Institute of Child Health and Human Development (R01HD078131; PI: Stephenson). Dr. Shrader's effort on this project was funded by the National Institute of Allergy and Infectious Diseases (T32AI114398, PI: Howard) and National Institute on Drug Abuse (R25DA050687, PI: Valdez; P30DA011041, PIs: Hagan, Ompad). Dr. Moody was supported by the National Institute on Drug Abuse (T32DA031099, PI: Hasin) and a grant from the National Center for Injury Prevention and Control, Centers for Disease Control and Prevention to the Center for Injury Epidemiology and Prevention at Columbia University (R49CE003096, PI: Branas). Dr. Knox's effort on this project was funded by the National Institute on Alcohol Abuse and Alcoholism (K01AA028199, PI: Knox) and the National Institute on Drug Abuse (R01DA054553, PI: Knox; R21DA053156, PI: Knox).

Availability of Data and Materials Data can be made available upon request to Rob Stephenson on an individual case by case basis.

Code Availability Code can be made available upon request to Cho-Hee Shrader on an individual case by case basis.

Declarations

Competing Interests The authors disclose having no conflicts of interest.

Ethical Approval and Consent to Participate Ethical approval for the present study was approved by the University of Michigan Institutional Review Board (HUM00182640). Participants provided online written informed consent.

Consent for Publication Not applicable.

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