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ORIGINAL PAPER

Daily Associations Between Alcohol Use and Unprotected Anal Sex Among Heavy Drinking HIV-Positive Men Who Have Sex with Men

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Abstract Men who have sex with men (MSM) account for the largest proportion of new HIV infections in the United States. Alcohol may facilitate HIV transmission by increasing unprotected anal sex, but few studies have focused on transmission behaviors in HIV-positive MSM. This study explored daily associations between alcohol use and sexual behavior among heavy drinking HIV-positive MSM using a 30-day Timeline Followback interview. Results of generalized estimating equations indicated that greater alcohol consumption on a given day was associated with a linear increase in the odds of having unprotected anal sex with partners of any HIV status. However, the odds of reporting unprotected anal sex with HIV-negative or HIV-status unknown partners increased in a curvilinear fashion, occurring primarily at very heavy levels of use (12+ drinks). Results suggest that very heavy drinking increases the risk of engaging in sexual behavior that has the potential for transmitting HIV to other men.

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Resumen Los hombres que tienen relaciones sexuales con hombres (HSH) representan la mayor proporción de nuevos casos de VIH en los Estados Unidos. El uso de alcohol puede facilitar la transmisión del VIH mediante el aumento de relaciones sexuales anales sin protección, pero pocos estudios se han enfocado en estos comportamientos entre HSH VIH-positivo. Este estudio exploró asociaciones diarias entre el consumo de alcohol y la conducta sexual entre HSH VIH-positivo utilizando la entrevista Timeline Followback de 30 días. Los resultados de las Ecuaciones de Estimación Generalizadas (GEE) indicaron que el mayor consumo de alcohol en un día determinado es asociado con un aumento lineal en las probabilidades de tener sexo anal sin protección sin importar si la pareja es portadora de VIH o no. Sin embargo, las probabilidades de informar sobre el sexo anal sin protección con parejas VIH-negativas o VIH estatus desconocido aumentó de forma curvilínea, ocurriendo principalmente durante situaciones de muy alto uso de alcohol (12 tragos o más). Los resultados sugieren que altos consumos de alcohol aumentan el riesgo de involucrarse en conductas sexuales que tiene el potencial de transmitir el VIH a otros hombres.

Keywords Sexual risk behavior · Men who have sex with men · Alcohol · HIV-positive

Palabras claves Conductas sexuales de riesgo · Hombres que tienen relaciones sexuales con hombres · Alcohol · VIH-positivo

Introduction

Despite relative stability in HIV incidence in the United States (U.S.) in recent years [1], rates of new HIV

infections continue to rise among men who have sex with men (MSM; 2). For example, in 2010, MSM accounted for 63 % of new U.S. HIV cases [1], up from 53 % in 2006 [3]. Rates of HIV infection among MSM continue to increase approximately 3 % each year [4]. Although the scientific scholarship focusing on HIV in MSM is extensive [5], increasing rates of new infections highlight the pressing need for further research devoted to understanding HIV transmission dynamics among MSM.

Alcohol Use and Sexual Risks

Alcohol use has a profound effect on the HIV epidemic, influencing a variety of HIV-related outcomes including the progression of disease and adherence to treatment [6, 7]. Perhaps no effect has received more attention than the role of alcohol in increasing HIV transmission risk [8]. In large part, alcohol is hypothesized to facilitate HIV acquisition by increasing the likelihood of engaging in unprotected sex [9]. As such, a robust literature has developed aimed at understanding associations between alcohol use and sexual risk behavior [10]. Global studies of alcohol use and sex risk, which focus on overall levels of both behaviors over broad recall periods, generally support an association between the two behaviors in heterosexual men and women [11, 12]. Also, experimental studies in which alcohol is administered and sexual intentions are assessed support a causal relationship between alcohol intoxication and risky sex [13]. However, event- and situation-level studies—those that focus on whether alcohol was consumed immediately before or during a recent unprotected sex event—have yielded largely mixed findings among heterosexual men and women [14, 15], and meta-analyses of the event- and situation-level research have suggested that unprotected sex may not be more likely when alcohol is used before or during heterosexual sex [16, 17]. Thus, although global and experimental research on the alcohol-risky sex link among heterosexual men and women points to an association, studies utilizing event- and situation-level methods have yielded equivocal support.

Fewer studies have focused on understanding the alcohol-risky sex association among MSM, a significant concern given the high risk for HIV acquisition for these individuals [18, 19]. A number of studies using global measures have generally linked various alcohol-related variables to risky sexual outcomes in MSM [20–22], with some exceptions [23–26]. Although preliminary, one published experimental study examining the alcohol-risky sex link among MSM supported an association between alcohol intoxication and intentions to engage in unprotected anal intercourse (UAI) [27]. Finally, in contrast to research in heterosexual populations, a recent review of event-level studies concluded that, across several studies of MSM specifically, binge alcohol use was consistently related to sexual risk outcomes such as UAI [28]. However, it is notable that nearly all of the studies included in this review focused only on one or two incident events, commonly the participants' last sexual encounter. Although such an approach is useful, examining the co-occurrence of alcohol use and risky sex at the daily level offers a number of important advantages, including comparison across multiple days with varying levels of each behavior. In addition, many of the reviewed studies also focused primarily on general outcomes that do not incorporate partner HIV serostatus, which is essential for understanding the risk for HIV transmission associated with a particular behavior. Specifically, few event-level studies have focused exclusively on HIV-positive MSM and the HIV status of the partners with whom they engage in unprotected sex.

The Present Study

The present study addresses a crucial gap in the HIV literature by examining, in HIV-positive MSM, daily associations between alcohol use and both (a) UAI and (b) UAI with a partner of HIV-negative or unknown serostatus. Specifically, we tested the hypothesis that incremental increases in alcohol use level on a given day would commensurately increase the odds of engaging in UAI, beyond the effects of both time-invariant individual characteristics assessed at baseline (including demographics, relationship status, depressive symptoms, and average level of alcohol and substance use), and time-varying substance use (including marijuana use and use of other drugs on a given day). Based on past findings [28], we hypothesized that particularly high levels of alcohol use on a given day would be uniquely associated with engagement in higher-risk sex. We also examined engagement in any anal intercourse (AI), whether protected or unprotected, to determine the extent to which alcohol use was broadly associated with an increased likelihood of engagement in AI overall versus having more specific associations with UAI or with UAI with HIV-negative or unknown status partners.

Method

Participants were enrolled in a project to develop and test a brief intervention to reduce heavy alcohol use among HIV-positive MSM; here we present on baseline, pre-randomization data. Participants were recruited from an urban community health center with a strong focus on sexual and gender minority health, caring for more than 2000 primarily MSM living with HIV. Data in this manuscript are derived from the first 109 men who participated in the project, enrolled from 2011–2013. For inclusion in the

larger trial, participants had to: (1) be at least 18 years of age; (2) drink heavily at least once per month on average (≥5 drinks) or drink more than 14 drinks per week; (3) have a confirmed diagnosis of HIV; (4) be a male who has had sex (oral or anal) with a male partner in the past 12 months. For those on antiretroviral therapy (ART), participants had to be stable on their current regimen for at least three months prior to study enrollment. Participants were excluded if they: (1) reported current intravenous drug use; (2) were currently psychotic, suicidal, or manic; (3) were currently being treated or had been treated in the past three months for an HIV-related opportunistic infection; or (4) were currently receiving treatment for an alcohol or drug problem.

Participants were recruited through flyers posted at the clinic or during scheduled visits with HIV care providers. Potential participants first completed a brief eligibility screen with study staff either in-person or by phone. Those who appeared eligible based on their responses were invited to participate in a baseline visit. Participants were asked to abstain from alcohol for 24 h before this assessment, and staff administered an alcohol breath analysis to confirm. At the baseline visit, participants first completed the informed consent process approved by the relevant Institutional Review Boards. They then completed confirmation screening for eligibility and the remainder of the baseline interview.

A total of 625 individuals were approached for screening at the clinic or called the study center to learn about participation. Of these, 239 declined to be screened, and 244 were determined to be ineligible for one or more of the following reasons: does not meet drinking criteria ($n = 157$), no sex in the past 12 months ($n = 42$), recent HIV medication initiated ($n = 17$), intravenous drug use ($n = 18$), current alcohol treatment ($n = 10$), not a patient at the participating health center ($n = 7$), involved in another behavioral intervention study ($n = 3$), current opportunistic infection ($n = 2$), not male or HIV-positive ($n = 3$), and investigator determination, which typically means that they had been disruptive in the clinic during their participation in a prior study ($n = 3$). Of the 142 who appeared eligible at screening, 121 completed a baseline assessment, of whom 12 were found ineligible: suicidal ideation ($n = 3$), does not drink enough ($n = 2$), recent HIV medication initiated ($n = 1$), and current mania ($n = 1$). An additional five participants were ruled out for current major depression early in the study before that exclusion was removed. In total, 109 were fully eligible and successfully completed a baseline interview and, thus, are represented in the sample here.

Measures

Current alcohol and substance use disorders, as well as current major depressive disorder, mania, and psychotic symptoms were assessed using the SCID-NP [29]. Depressive symptoms were assessed using the Center for Epidemiologic Studies—Depression scale (CES-D) [30].

The Timeline Followback interview (TLFB) [31] was used to assess day-level alcohol and drug use for the 30 days prior to the assessment. The TLFB interview is a calendar-assisted, structured interview which provides a way to cue memory to enhance recall accuracy. A structured interview of drinking behavior has been found to be the most reliable and valid method of assessing alcohol and drug use [32–34]. The TLFB interview has demonstrated excellent reliability [35] and validity [32]. The TLFB assessed the number of standard drinks of alcohol consumed on each day (defined as 12 oz. of beer, 5 oz. of wine, or 1.5 oz. 80-proof liquor), and whether various categories of drugs (e.g., marijuana, cocaine, heroin, "poppers") were used.

The TLFB was also used to assess sexual behaviors and was completed on the same calendar after assessing alcohol and drug use. The TLFB for sex risk behavior assessment has previously been shown to be feasible, reliable, and valid [36] and has been used extensively with MSM [37]. This interview assessed each occasion of sexual activity over the past 30 days, with detailed information on the type of partner (regular, i.e., a partner from a dating or long-term relationship; casual, i.e., a partner who is either a friend, acquaintance, or known solely in the context of a sexual encounter); HIV status of partner (positive, negative, or unknown); type of sexual activity (oral, anal insertive, anal receptive, vaginal insertive [none was reported in the current sample]); condom use; and whether the participant was under the influence of alcohol and/or drugs at the time of sex. Although participants could specify sexual behaviors with up to four partners per day on the TLFB, binary indicators for each type of sexual behavior (e.g., unprotected anal intercourse with an HIV-infected partner) were coded to reflect the presence or absence of that behavior on a given day, across partners/episodes. TLFB data were almost entirely complete, with only six days out of the total of 3,270 days assessed (0.92 %) having any missing data.

Analysis Plan

We examined daily associations between time-invariant and time-varying variables and three sexual behaviors: any AI (protected or unprotected), UAI, and unprotected receptive or insertive anal intercourse with a partner of negative or unknown HIV status. We also included a time-varying term that carried, as a linear effect, four levels of alcohol use on a given day: (0) 0 drinks, (1) 1–4 standard drinks, (2) 5–11 standard drinks, and (3) 12+ standard drinks. In addition to this linear term, which was centered prior to analysis, we tested potential quadratic associations between daily alcohol

use and sex outcomes. If the alcohol use term was significant, we ran a separate model to test pairwise odds ratios for each drinking category compared to the no drinking category. Guidelines from the National Institute on Alcohol Abuse and Alcoholism classify five or more drinks on a given day as heavy drinking for men—drinking that poses a higher risk for alcohol-related problems [38]. For men with high average levels of consumption (i.e., 2–4 drinks per day), drinking 12+ drinks on any day confers added risk for alcohol problems compared to drinking 5+ drinks [39].

To test these models, we conducted generalized estimating equations (GEEs) in Stata 13 (Stata Corporation, 2013), specifying binomial distributions with logit link functions. We employed a build up strategy for incorporating time-invariant and time-varying variables of interest. Initial models included individual-level, time-invariant variables of interest—including the average number of drinks per drinking day, and percentage of drug use days across the 30-day TLFB—as well as a binary variable indicating whether that participant only reported sex with a steady partner during the recall window. We initially included relevant demographic variables (age, income, race, and education) in this first step, but since none of those demographic variables were significantly predictive of the dependent variable in any of the models, we dropped demographic variables from the analyses. The other static variable entered at this step was participants' total score on the CES-D, minus the somatic subscale (because of potential overlap with expected somatic symptoms of HIV disease [40]); we considered depressive symptoms a potential confounder in the alcohol-sex association because of its association with both alcohol consumption and sex risk in MSM [41, 42]. Given previous results suggesting a possible curvilinear association between depressive symptoms and sex risk [42], a quadratic term was tested at this step. In the second step of the model, the linear and quadratic effects of alcohol use on a given day (i.e., the time-varying effects) were added. In the final step, we entered time-varying substance use variables to examine whether associations between alcohol use and the study outcomes held over-and-above drug use. We entered day-level marijuana use and day-level other drug use, which included use of any other drugs, including methamphetamine, cocaine, heroin, and others. Poppers or amyl-nitrate inhalants, were excluded, because they are often used immediately before or during sex, after decisions about sexual arrangements have been made (e.g., positioning, condom use [43]).

Results

Descriptive Statistics

Table 1 shows the demographic characteristics of the sample. These participants provided data for a total of 3,270 person-days. Across the sample, participants reported a total of 1,051 sex acts with 634 partners over the 30-day recall period. Participants reported an average of 9.64 sex acts ($SD = 12.35$), and an average of 5.09 sex days ($SD = 5.34$) over the 30-days. Oral sex took place during 89.0 % of all sex events, and 40.3 % of these took place with casual partners. Insertive anal sex took place during 36.9 % of all sex events, with 45.3 % reported to have occurred with casual partners. Receptive anal sex took place during 39.4 % of sex events, with 28.4 % attributed to casual partners. Forty-three percent of participants reported only having sex with regular partners, while

Table 1 Demographic characteristics of the analyzed sample (N = 109)

Characteristics	Mean (SD) or *N* (%)
Age (range: 20–63, $M \pm$ SD)	42.5 (10.6)
Race	
White	77 (70.6)
Black or African American	26 (24.8)
American Indian/Alaska Native	5 (4.6)
Asian	1 (0.9)
Ethnicity (Hispanic or Latino)	20 (18.3)
Marital status	
Single/never married	54 (49.5)
Married/domestic partnership	26 (23.9)
In a committed relationship	14 (12.8)
Divorced/separated	9 (8.3)
Widowed	4 (3.7)
Education	
Some high school	2 (1.8)
High school diploma/GED	13 (11.9)
Some college education	39 (35.8)
College graduate	22 (20.2)
Some graduate school	10 (9.2)
Technical or business school	8 (7.3)
Graduate or professional degree	15 (13.8)
Income	
$0–$29,999	51 (46.8)
$30,000–$99,999	37 (33.9)
$100,000 or more	20 (18.3)
Sexual identity	
Gay/homosexual	101 (92.7)
Bisexual	6 (5.5)
Other	2 (1.8)
Years since HIV diagnosis	10 (7.7)
On antiretroviral therapy	99 (90.8)
Detectable viral load (>75 copies)	11 (10.1)
Number of drinks per week	22.1 (21.8)
% Alcohol dependent	41 (37.6)
% Substance dependent (non-alcohol)	15 (13.8)

Table 2 Pairwise correlations for study variables in the generalized estimating equations models

Variables	1	2	3	4	5	6
1. Total # of AI days						
2. Total # of UAI days	0.56*					
3. Total # of high-risk AI days	0.47*	0.70*				
4. Avg. drinks per drinking day	0.09	0.13	0.27*			
5. % drug use days	0.19*	0.23*	0.28*	0.45*		
6. Steady partners only	0.13	−0.07	−0.18	−0.25*	−0.12	
7. CES-D (HIV) total	0.01	−0.17	−0.03	0.07	0.19	−0.06

AI anal intercourse, *UAI* unprotected anal intercourse. High risk AI is defined as UAI with an HIV-negative partner or a partner of unknown serostatus. *CES-D* Center of Epidemiologic Studies-Depression scale

* $p < .05$

33.7 % reported only having sex with casual partners, and 23.6 % reported sex with both types of partners. Ninety-six percent of all oral sex events were unprotected, while 70.9 % of all insertive anal intercourse events were unprotected, and 56 % of all receptive anal intercourse events were unprotected. Thus, 62.1 % of all anal sex events did not involve condom use, and 28.9 % of all anal sex events were unprotected with partners of negative or unknown HIV status. A total of 44.0 % of participants reported engaging in AI without a condom. A total of 23.9 % of participants reported engaging in unprotected insertive or receptive anal sex with a partner of negative or unknown HIV status. A total of 116 such events were reported, for an average of 4.5 occasions ($SD = 4.9$) across 4.1 days ($SD = 4.0$) of the 30-day recall period.

Participants reported drinking on an average of 16.5 ($SD = 8.4$) days assessed (i.e., 53.3 % of days), with a mean of 5.8 ($SD = 3.7$) drinks per drinking day; an average of 7.5 ($SD = 6.8$) heavy drinking days (defined as consuming 5 or more drinks on a single day) across the 30-day recall period; and an average maximum drinks per day of 12.0 ($SD = 8.8$). Thirty-nine percent of participants reported drinking 12 or more drinks at least once over the 30-day period, and these participants reported an average of 4.5 ($SD = 5.4$) such days over this period. Seventy percent of all sex acts (oral, insertive anal, receptive anal) occurred on a drinking day. Similarly, 79.9 % of all unprotected insertive anal sex occurred on a drinking day, while 74.8 % of all unprotected receptive anal intercourse events occurred on a drinking day. Finally, 80 % of unprotected insertive or receptive anal sex with a partner of negative or unknown HIV status occurred on a drinking day.

Participants reported being under the influence of alcohol or drugs during 62.9 % of all sex acts. Of all unprotected insertive anal sex events, 76.5 % occurred while under the influence of alcohol or another substance. Similarly, 73.57 % of all unprotected receptive anal sex events occurred under the influence. Finally, participants reported being under the influence during 83.6 % of the events in which they had unprotected insertive or receptive anal sex with a partner of negative or unknown HIV status.

Daily Models of Sexual Behaviors

Table 2 displays the correlations among the static individual characteristics and the respective dependent variables included in the first step of the GEE models. The sexual behavior outcomes were strongly correlated with each other as would be expected, but at least 50 % of the variance in each was independent of any other behavior. Greater average drinks per drinking day was strongly positively correlated with frequency of drug use, and having sex only with a regular partner was associated with a lower number of drinks per drinking day.

Any Anal Intercourse (AI; Protected or Unprotected)

As shown in Table 3, participants' overall percentage of drug use days was the only static variable in model 1 found to be associated with engaging in any AI, but this term was not significant in subsequent models. In model 2, time-varying (i.e., day-level) alcohol use was significantly related to an increased odds of having AI on that day, such that each increase in drinking level on a given day increased the odds of engaging in anal intercourse two-fold. As the quadratic alcohol use term was nonsignificant, it appears that this association was linear. Figure 1 depicts odds ratios for each drinking category by outcome. Comparisons between each drinking category against the reference group lend further support to linear increases in the odds of AI, indicating that consuming between 1–4 drinks on a given day was not associated with significant increases in the odds of engaging in AI ($OR = 1.19$, $p = .364$, CI 0.82–1.74) compared to not drinking. Consuming between 5–11 drinks, however, was related to a two-fold increase in

Table 3 Generalized estimating equations (GEE) for daily reports of engaging in any sexual behavior, UAI, and high-risk AI

Variable	Any AI				Unprotected AI				High-risk AI			
	OR	SE	*p*	95 % CI	OR	SE	*p*	95 % CI	OR	SE	*p*	95 % CI
Model 1												
Avg. drinks/drink day[a]	0.99	0.04	.703	0.91–1.06	1.00	0.04	.938	0.93–1.09	1.06	0.04	.147	0.98–1.15
% drug use days[a]	1.02	0.01	.012[b]	1.00–1.03	1.02	0.01	.004[b]	1.01–1.04	1.02	0.01	.012[b]	1.00–1.03
Steady partners only	1.30	0.38	.362	0.74–2.29	0.84	0.30	.628	0.42–1.69	0.49	0.29	.232	0.15–1.58
CES-D (HIV)	0.94	0.05	.239	0.85–1.04	0.93	0.02	.002	0.88–0.97	0.96	0.03	.117	0.90–1.01
CES-D (HIV) (quad)	1.00	0.01	.262	0.99–1.00	1.00	0.01	.815	0.99–1.01	1.00	0.01	.513	1.00–1.01
Model 2												
Daily alcohol use[c]	2.02	0.20	<.001	1.66–2.46	1.99	0.22	<.001	1.60–2.48	1.09	0.32	.777	0.61–1.95
Daily alc use (quad)	1.20	0.25	.381	0.80–1.80	1.08	0.24	.738	0.69–1.67	1.65	0.40	.038	1.03–2.64
Model 3												
Daily alcohol use	1.91	0.19	<.001	1.57–2.33	1.87	0.21	<.001	1.50–2.32	1.00	0.29	.996	0.57–1.76
Daily alc use (quad)	1.14	0.24	.520	0.76–1.74	1.04	0.24	.861	0.67–1.62	1.65	0.36	.024	1.07–2.53
Daily marijuana use	1.09	0.33	.785	0.60–1.97	0.91	0.35	.803	0.42–1.95	0.65	0.46	.538	0.16–2.56
Daily other drug use	3.55	1.43	.002	1.61–7.84	4.50	2.03	.001	1.85–10.90	4.55	2.23	.002	1.74–11.91

AI anal intercourse, *OR* odds ratio, *SE* standard error, *CES-D* Center of Epidemiologic Studies-Depression scale. High risk AI is defined as UAI with an HIV-negative partner or a partner of unknown serostatus. Models 2 and 3 contain all of the covariates in Model 1

[a] Averaged over the full 30-day recall period

[b] Effect became nonsignificant when daily alcohol use was added in Model 2

[c] Coded each day as 0 = no drinking, 1 = 1–4 drinks, 2 = 5–11 drinks, and 3 = 12+ drinks

odds ($OR = 2.12$, $p < .001$, CI 1.42–3.15), while consuming 12+ drinks was associated with nearly a four-fold increase in odds ($OR = 4.12$, $p < .001$, CI 2.41–7.04). This suggests that the amount of alcohol use on a given day is associated with an incremental increase in the odds of engaging in AI on that same day. Moreover, although other drug use on a given day was also associated with engaging in AI, entering the time-varying drug use variables in model 3 did not result in substantive changes to the associations between alcohol use and sex.

Unprotected anal Intercourse (UAI)

In model 1, CES-D score was associated with a linear decrease in odds of having engaged in UAI. Overall percentage of drug use days was also significantly associated with UAI in this model, but was nonsignificant in later models. In model 2, daily drinking category was again associated with an overall increased odds of having engaged in UAI on a given day. The quadratic term was, again, nonsignificant. Pairwise comparisons of specific drinking categories with the reference group (no drinking) suggested a pattern of associations similar to those in the previous model. That is, having consumed 1–4 drinks on a given day was not significantly associated with an increased odds of engaging in UAI ($OR = 1.07$, $p = .765$, CI 0.70–1.63) relative to not drinking. However, consuming 5–11 drinks on a given day was associated with a two-fold increase in the odds of UAI ($OR = 2.14$, $p = .001$, CI 1.34–3.42), and drinking 12 or more was associated with a 4.5-fold increase in odds ($OR = 3.51$, $p < .001$, CI 2.03–6.06). These associations remained significant after adding in time-varying drug use variables; other drug use on a given day was independently associated with an increased odds of UAI.

Unprotected AI with an HIV-Negative or Unknown Status Partner

In model 1, only the overall percentage of drug use days was significantly associated with having engaged in UAI with a partner of HIV-negative or unknown status but, again, this term was nonsignificant in later models. In model 2, the linear effect of alcohol use level on a given day was nonsignificant; however, there was a significant quadratic effect of alcohol use level on a given day, suggesting that alcohol use and high risk AI may not co-vary in a linear fashion. Odds ratios for each drinking category relative to the reference group were consistent with that interpretation. Neither of the lowest two drinking categories (1–4 drinks and 5–11 drinks) were significantly associated with increased odds of UAI with negative and unknown serostatus partners on a given day compared to not drinking. However, consuming 12+ drinks, compared to not drinking, was associated with a nearly 6-fold increase in the odds of engaging in sexual activity that

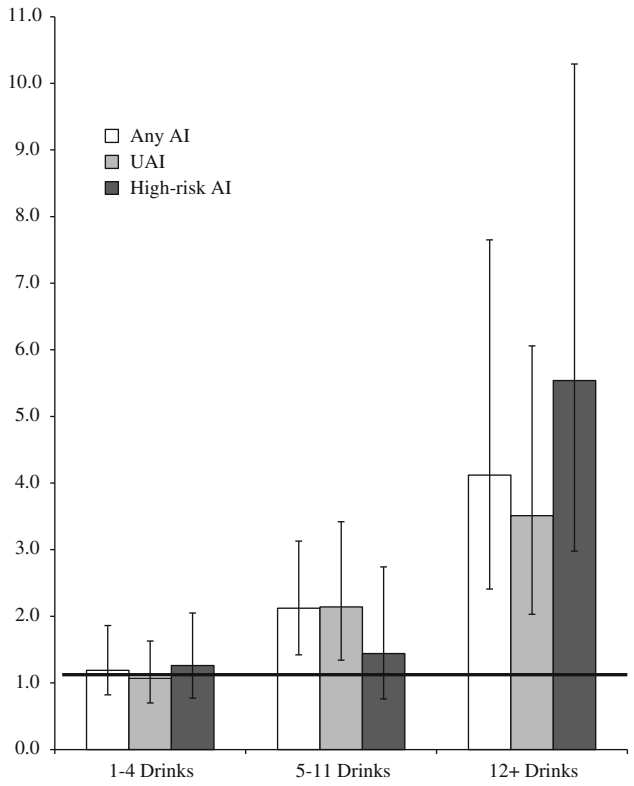

Fig. 1 Odds ratios estimated from GEE models for engaging in sexual behaviors by daily alcohol use category with no alcohol use as the reference group. *AI* anal intercourse, *UAI* unprotected anal intercourse. High-risk AI is defined as UAI with an HIV-negative partner or a partner of unknown serostatus

poses a potential risk for HIV transmission ($OR = 5.54$, $p < .001$, CI 2.98–10.29). Similar to previous models, these results also held after entering time-varying drug use variables into the model, and other drug use was significantly associated with increased UAI. These results suggest that very high levels of alcohol use on a given day are associated with a significant rapid escalation in the odds of having sex that can pose a risk for transmitting HIV to an uninfected partner.

Discussion

This is among the first studies to examine the day-level covariation between alcohol use and sexual behavior that may pose a risk for HIV-transmission among HIV-positive MSM. Using data from the TLFB enabled us to examine levels of daily alcohol use, ranging from no alcohol use to very heavy drinking (12+ drinks), and to examine both whether protection was used during each episode of AI and the serostatus of the partner involved. Results largely confirmed our hypothesis that greater alcohol use would be associated with greater odds of AI in a linear fashion. That is, with each increase in level of alcohol consumption, the odds of engaging in any AI increased steadily. This association between drinking and sex could occur through a variety of mechanisms. For example, the association between alcohol use and sex on a given day may reflect common situational or environmental antecedents, such as having more free time on weekends or going to clubs or parties, which may contribute to the opportunity to engage in either behavior. MSM also may use alcohol intentionally as a means to facilitate sex and reducing sexual inhibitions, since many people hold expectancies that ingesting alcohol will bring about those effects [44].

Heavy alcohol use also may lead to sex through reduced inhibitory control, causing people to make decisions regarding sex they would not make otherwise. In fact, the odds of engaging in AI on a drinking day only became significantly greater than the odds of AI on a nondrinking day when participants consumed 5+ drinks, a level consistent with significant intoxication; the odds of AI was almost 4 times higher when participants drank 12+ drinks compared to days when they did not drink. On the other hand, there was little evidence that higher levels of drinking had a particularly strong effect on UAI compared to AI—which would be expected if riskier sex were to be the result of intoxication's interference with intentions to use barrier protection. AI and UAI showed such similar associations with levels of alcohol consumption such that it seems likely that both co-occur with drinking for similar reasons.

Much of the UAI reported by the men in the sample was with known seroconcordant partners, in which the biological risks are limited to acquiring other sexually transmitted infections [45]. UAI with partners who are HIV-negative or of unknown status showed a different association with alcohol use compared to UAI with any partner type and for any AI. Specifically, the odds of UAI with serodiscordant or unknown status partners followed a J-shape or quadratic curve, in which the odds of this behavior was only significantly increased relative to nondrinking days on days when participants drank 12 or more drinks. Thus, for AI that may pose a risk for HIV transmission between MSM, high levels of alcohol use seem to play a specific role. We can speculate, then, that when men are highly intoxicated, they may become less attentive to risks associated with UAI with HIV-negative or unknown status men and, therefore, would be more likely to put their partners at risk for HIV acquisition.

Aggregate metrics of alcohol and drug use over the prior 30 days were not associated with increased odds of engaging in AI or UAI of any type. These findings are consistent with a number of studies that fail to find support for associations between aggregate measures of alcohol use, such as drinking frequency and quantity over a period

of one or more months, and sexual risk behavior among MSM [24–26]. Thus, efforts to better understand the association between substance use and sexual behaviors should employ day-level data. In fact, day-level drug use data were highly associated with odds of AI, UAI, and UAI with HIV-negative or unknown partners. Alcohol and drug use on a daily level appeared to have relatively independent effects on sexual behavior.

Limitations

Although this study has a number of critical strengths, including detailed day-level analysis of a sample of exclusively HIV-positive MSM, there are several limitations to be noted. First, this study utilized TLFB methodology to assess the majority of study outcomes. Although reports of alcohol and drug use and sexual behavior on the TLFB over 30-day recall windows have been shown to be reliable and valid in previous research [46], retrospective recall always carries some risk of bias. This was a study of associations, rather than one testing a specific theory of how alcohol affects sex risk. Future studies should seek to extend these results using methods such as ecological momentary assessment that can assess behaviors more proximal to their occurrence, and provide a more in-depth, theoretically informed analysis of alcohol's role in the context of multiple determinants of sexual risk such as condom use intentions, drinking behavior of the partner, and environmental contexts in which the sex occurs.

It is important to emphasize that this study focused on a sample of heavy-drinking MSM living with HIV engaged with outpatient medical care. The vast majority of participants in the study had undetectable viral loads. Therefore, their actual risk of HIV transmission may be quite modest, and the fact that they are virally suppressed could influence their behavioral intentions regarding sex [47]. Heavy-drinking HIV-positive MSM who have not been diagnosed, or who are not well-connected with care, are a high priority to study; they are likely to be far more infectious than those engaged with care due to potentially higher viral loads, and may engage in higher rates of heavy drinking and risky sexual behavior. It also is important to study MSM who are HIV-negative, since their decision-making about sexual risk behaviors is likely to differ from those men living with HIV, potentially altering how alcohol relates to their sexual risk behaviors.

Conclusions

These findings add valuable information to the underdeveloped body of research on daily associations between alcohol use and sexual risk behavior among HIV-positive MSM, and suggest that behaviors posing higher risk for HIV transmission occur on days when alcohol is used at especially high levels. Across all models, use of drugs other than marijuana on a given day significantly increased the odds of engaging in AI, including UAI with uninfected partners, which is consistent with prior research on UAI in MSM (see Ref. [28] for a review). Interventions to address sexual risk behavior in HIV-infected MSM should therefore attend both to heavy drinking and the use of other drugs. An important question for future research is to address the extent to which (a) very heavy drinking and drug use occur as part of an intentional effort to become intoxicated and have sex [48] or (b) very heavy drinking and drug use lead to intoxicating effects that catalyze sexual activity and reduce the cognitive ability to inhibit unplanned risky behavior or enact protective behaviors such as condom use. For MSM living with HIV, counseling should address the fact that very heavy drinking poses a potential risk for engaging in sex with transmission risk.

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